LATE QUATERNARY PALAEOECOLOGY OF THE CENTRAL AND MARGINAL UPLANDS OF THE KAROO, SOUTH AFRICA.

BY

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ABSTRACT

LATE QUATERNARY PALAEOECOLOGY OF THE CENTRAL AND MARGINAL UPLANDS OF THE KAROO, SOUTH AFRICA.

Pollen analysis of organic sediments from vleis in upland areas of the Central and marginal Karoo has provided a vegetation history spanning the late Quaternary in the Winterberg, Sneeuberg, Nuweveldberg and Cederberg Mountains.

Fossil pollen studies indicate moist conditions at the beginning of the Holocene, followed by a drier period. The second half of the Holocene (4 600 BP) is characterised by moister conditions, becoming drier towards the present and resulting in a decline in grasslands and an increase in Karoo-bushes. In the western Cape, the late Pleistocene (15 000 to 10 000 BP) was characterised by conditions moister than the present. This was followed by a drier period which ameliorated in the late Holocene. Although climatic fluctuations occurred, fynbos has been maintained *in situ* throughout the sedimentation period (14 600 BP), highlighting the dominant role of the substrate and secondary importance of climate. Climatic changes caused a shuffling of plant communities within the Fynbos Biome - this long uninterrupted history may be one reason for the high species diversity of fynbos.

San hunter-gatherers, who occupied southern Africa prior to 4 000 BP, had a negligible impact on the vegetation. Khoi herders, who were first documented in the fossil record about 1 800 BP, had a slight impact on the vegetation, particularly by altering the fire regime. However, the arrival of European Trekboers some four hundred years ago had a significant effect on the environment. Although the general climatic trend in the Karoo is one of a drier phase, the decline in grasses and eastward movement of xeric Karroid elements has been accelerated due to mismanagement and sedentary farming techniques.

An extensive contemporary pollen rain study has been undertaken to examine the representivity of these fossil pollen data. The investigation shows that contemporary pollen rain is a good reflection of the vegetation communities in the Karoo and Cederberg. Multiple discriminant analysis compares fossil pollen assemblages with contemporary pollen spectra and proved useful for determining whether modern analogues exist for the fossil pollen assemblages. TWISA confirmed the zones derived from discriminant analysis. Environmental changes have occurred in the Karoo during the late Quaternary, resulting in fluctuations and changes in vegetation patterns which have been accelerated in the recent past by human activity.

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CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION.

Environmental change has recently occupied a significant place in the environmental sciences (Goudie, 1977). From various lines of evidence, it has been recognised that the earth's climate is a dynamic system and climatic fluctuations during the last two million years have had a marked effect on the environment (Hamilton, 1982). Environmental history of the temperate latitudes in the northern hemisphere, particularly for the Quaternary period, is fairly well established due to the advancement of techniques used to elucidate past climates. In southern Africa however, there are relatively few biological studies investigating environmental fluctuations. The paucity of evidence for this extensive area may be attributed to the arid climate which prevails over a large proportion of the country, a fact which entails that there are few sites of organic sediment accumulation. South Africa is accordingly, still in the pioneering stages of palaeoecological studies.

Environmental changes can be detected in various types of evidence, for example changes in lake-level, palynological, geomorphological and archaeological evidence, as well as radiometric (isometric) dating (Goudie, 1977). Environmental changes must in turn affect all components of the ecosystem, and are therefore assumed to be reflected by changes in vegetation patterns. The vegetation history of an area may be established from palynological evidence, pollen being well preserved in peat or other types of anaerobic, organic-rich, stratified sediment deposit. Pollen analysis, therefore, coupled with radiocarbon dating of organic sediments, may indicate vegetation and through

this, climatic changes. As a tool in the elucidation of former environments, pollen analysis is unequalled in the temperate, humid conditions of the northern hemisphere, but is less widely applied in tropical and arid regions, particularly in the southern hemisphere (Meadows, 1985a).

Interpreting environmental changes and vegetation history is essential because without recourse to evidence from the past, it is difficult to understand the contemporary plant spatial distribution patterns. As Meadows (1985a) points out, Charles Lyell argued that the present is a key to the past, but for the biogeographer it is equally valid to say that the past is a key to the present. Pollen analysis has developed as one of the more important techniques in Quaternary palaeoecological reconstruction, such that the chronology and nature of much of the last two million years is now reasonably well known. However, the picture of vegetation change in areas outside Europe and North America is far from complete and in southern Africa, where the relatively xeric climates do not favour the development of organic sediments and where permanent natural lakes are few, palynological studies are still in their early stages of development. Hence, relatively little is known of the late Quaternary environmental changes in southern Africa and no detailed Holocene sequences of change or models have been documented.

This study focuses on the Karoo Region (see Figure 3.1), which occupies extensive semi-arid areas in the interior of southern Africa south of the Orange River and encompasses a great diversity of climates, landforms, soils and vegetation. Reconstructing a vegetation history is more of a problem in complex, but delicate and sensitive ecosystems like the Karoo, where relatively small environmental perturbations may result in large shifts in vegetation distribution patterns and productivity. Another problem, in this semi-arid environment, is the availability of sites which are suitable for the accumulation of waterlogged

organic peats or sediments. The distribution and formation of this sort of site is largely controlled by climate; consequently the dry climatic conditions of the Karoo Biome are not conducive to pollen preservation. The problem of finding suitable polleniferous sites is, to some degree, overcome by searching in the areas of higher altitude, where moisture content is slightly higher and, therefore, conditions are more conducive to the accumulation of organic sediments. Suitable "vleis", containing polleniferous organic sediments, have been located on many of the mountains of the Great Escarpment and Folded Mountain Belt. In this study, suitable sediments containing fossil pollen grains deposited in a stratigraphically consistent manner, have been examined in vleis found on the Winterberg, Sneeuberg, Nuweveldberg and Cederberg Ranges. Butzer (1984a) has pointed out that there have been many meaningless generalisations devised from southern African Quaternary studies in the recent past. This is attributed to the paucity of data for the subcontinent. Furthermore, it suggests that these detailed regional case studies are an essential part of the environmental "jigsaw puzzle" (Meadows and Meadows, 1988).

In addition to the microfossils found in the "vleis", older fossils may be found in the solid geology and in sediments of the Karoo age. However, it is felt that the history of the late Quaternary has great significance in shaping contemporary distribution patterns and the period is more "visible" than earlier geological times. There are three main priorities for the establishment of a late Quaternary vegetation history of the Karoo. Firstly, the identification and collection of organic sediments from which the pollen is extracted to produce the pollen diagrams. Secondly, radiocarbon dating of sediments to yield a detailed chronology of the vegetation change. Thirdly, an extensive sampling programme of the contemporary pollen rain is required in order to place the fossil analysis in the context of modern Karoo plant communities.

Although there may be various factors which have been important in shaping the vegetation of the Karoo today, viz. evolution, migration, speciation and autogenic changes; environmental changes, especially those occurring during the late Pleistocene and Holocene have been of fundamental significance and need to be investigated. To elucidate these environmental changes, it is wise to gather in as many different types of evidence as are available, including micro- and macro-fossil evidence, historical diaries and zoogeographical and phytogeographical evidence gleaned from an analysis of contemporary distribution patterns. There has thus been a trend in recent years for palaeoenvironmental analyses to be conducted on a multidisciplinary level, where a variety of different types of palaeoenvironmental evidence has been utilised to produce a more coherent picture of the environmental changes which have taken place. This is especially necessary for studies of the Quaternary in southern Africa, because the environmental conditions that prevail often entail that particular kinds of material, especially fossil pollen, are not suitable for analysis. With a variety of lines of evidence to augment the palynological information, a clearer idea and understanding of the past vegetation assemblages of the Karoo may be obtained.

The upland regions of the Karoo, which are investigated in this project (see Figure 3.2), form an east-west transect across the Karoo Biome, from the Winterberg in the east to the Cederberg in the west. These upland regions extend from the convergence zone of the Tongoland-Pondoland phytochoria (White, 1983) to the Mountain Fynbos in the west and include Afromontane elements, fynbos of the Capensis Region and shrublands of the Karoo-Namib Region (Cowling, 1983). Due to the paucity of sites suitable for the preservation of palynological and other fossil evidence in this extensive semi-arid region, little is known of the palaeoenvironments and few, if any, radiocarbon-dated pollen diagrams are

available. The four study areas are separated by extensive Karoo plains and therefore local findings cannot be inferred to have occurred at all the sites, or in the Karoo as a whole. Some caution is necessary, particularly for sites situated on the edges of the Karoo adjacent to very different environments. These marginal sites must, of necessity, reflect patterns slightly different from those to be expected in the central areas of the Karoo. According to Cowling (1983), an important part of an historical approach to vegetation assemblages is the phylogenetic analysis of taxa and also the analysis of vicariance, speciation and endemism. An understanding and comprehensive knowledge of the functioning of contemporary vegetation assemblages is therefore necessary before one begins to explain and interpret vegetation distribution patterns of the Holocene.

Pollen analysis of one of the few spring deposits at Aliwal North which is on the periphery of the Karoo, was investigated by Coetzee (1967). These results suggest that the Karoo may have expanded and contracted a number of times during the late Quaternary. Acocks (1953 and subsequent editions in 1975, 1988) has also suggested that the sparse Karroid vegetation of southern Africa is spreading eastwards due to human activities. However, this expansion, due solely to mismanagement of the environment, has been contended. Van Zinderen Bakker (1978) describes fluctuations in the Karoo and suggests that humans are not the dominant determinant of vegetation distribution, rather that vegetation has determined human distribution. Nonetheless, little is known of the vegetation changes within the Karoo Biome, particularly during the late Quaternary and Holocene periods. It is thus the aim of this study to obtain evidence from sites in and around the Karoo, so as to determine whether the Biome has, in fact, fluctuated in extent in response to climatic fluctuations of the late Quaternary period. The purported spread of the Karroid vegetation in an easterly direction may also be examined, particularly from evidence obtained in the

Winterberg and Sneeuberg Mountains at the eastern margins of the contemporary Karoo.

1.2 AIMS AND SPECIFIC OBJECTIVES.

Little is known, therefore, of the vegetation changes within the Karoo Biome, and it is hoped that this study will elucidate environmental and climatic changes which occurred during the late Pleistocene and Holocene periods. The principal aim of this study is to provide pollen records of the past vegetation assemblages and date the sediments deposited in the vleis of the Cederberg, Nuweveldberg, Sneeuberg and Winterberg Mountains of the Karoo. By gaining knowledge of the history of a vegetation type or of a taxon, one may offer a more reasoned explanation for present-day distributions and hence manage the present environment more effectively.

More specifically, the objectives of this study are as follows:

1. To construct a pollen reference collection of the contemporary pollen-producing species of the Karoo Biome and surrounding areas.
2. To improve the appropriateness of the vegetation history by conducting an extensive contemporary pollen rain programme.
3. To provide a vegetation history record for each of the study areas.
4. To examine how the vegetation has responded to environmental changes and to infer climatic changes from the vegetation history.
5. To date basal and other sediments from the cores taken from each study area.
6. To assess the correlation between the chronology of organic sediment accumulation and the vegetation history from sites in and around the Karoo.

From this study, the dynamic nature of the Karoo Biome in response to environmental fluctuations can be established. Broadly speaking, the aim is therefore to establish a late Quaternary palaeoenvironmental history of the Karoo, South Africa, but more specifically it is to focus on the upland areas of the Cederberg, Nuweveldberg, Sneeuberg and Winterberg Ranges.

CHAPTER 2

ENVIRONMENTAL CHANGE IN SOUTHERN AFRICA

2.1 INTRODUCTION.

Environmental change is a basic concern in the consideration of the relationship between people, their landscape and the environment in general and has therefore become a major focus of the attention for participants in many disciplines. Closer to the present day, the relationships of environmental change to human affairs are more evident, not the least due to the ever-increasing population and associated pressure on the natural environment. The earth's climate is a dynamic system which is constantly changing, such that climatic fluctuations during the Quaternary period have had a profound effect on the environment (Hamilton, 1982). Climate and its variability have always been major environmental determinants with which mankind has had to contend. Over millennia climate has shaped civilisations and today the living habits of people have become adjusted to the conditions of the last century (Tyson, 1986). This is particularly so in regions where great pressures are placed upon the natural resources, the balance of which may be seriously affected by small changes in climate.

The Quaternary period may have been very short in relation to the total age of the Earth, but environmental changes which have occurred during the time that man has been an inhabitant of the Earth have not been slight. These changes, whether in climate, sea-level, vegetation, animal populations or soils and landforms, have been both numerous and large in scale (Goudie, 1981). Environmental changes occurring during the late Pleistocene and Holocene periods are relatively well documented, more "visible" than earlier

geological time and thought to have been of significance in shaping contemporary biotic distribution patterns.

Most researchers are in agreement that the late Quaternary palaeoenvironmental adjustments are directly or indirectly related to the global cycle of glacial and interglacial events. Since the boundaries of plant and animal distributions are controlled, in part, by climatic factors, it stands to reason that any changes in such factors could result in a change in distribution patterns. Changing global temperatures have been the primary factor initiating climatic changes that in turn led to adjustments in plant and animal community structure and the disruption of cycles of deposition and erosion. The inherent nature of the earth's environmental conditions to fluctuate entails that plant species which are adapted to a given range of environmental conditions are constantly having to adjust their particular ranges. There are problems of tautology in interpreting this environmental change, since much of the evidence of a floristic or biogeographical nature is used to retrodict a particular environmental oscillation, which is then, in turn, used as supporting evidence for changing distribution characteristics of other species (Stott, 1981). Notwithstanding this, there seems little doubt that the vegetation history, usually elucidated through pollen analysis, is a major piece in the environmental "jigsaw puzzle".

To investigate the climatic and environmental reactions to these fluctuations in temperature, one needs to be able to accurately interpret the clues that are preserved within the fossil records. By using a combination of inductive and deductive methods, patterns of change are discerned and are then explained using modern analogues. To understand the nature and origin of present-day soils, landforms and floral and faunal distributions, it is essential to be aware of their history and evolution. Many features of the environment are not necessarily in equilibrium with present

processes and thus it is sometimes inappropriate to examine them purely in terms of currently functioning systems or modern analogues.

In the past few decades the study of environmental change has been transformed by the development of new techniques for dating and temperature assessment (Goudie, 1977). Of special interest has been the radiometric or isotope techniques, especially radiocarbon, uranium series and potassium-argon. These three isotopic dating techniques all depend on the measurement of emission by elements which, through time are either formed by, or are subject to, radioactive decay. In addition, great use has been made of a palaeomagnetic calendar of magnetic events (Cox *et al.*, 1967). These techniques have enabled more accurate absolute dating for events over an extended time-scale, facilitating both temporal and spatial correlations which, prior to their use, had been extremely hazardous. These techniques, combined with the expansion of scientific exploration into areas hitherto neglected (notably parts of South America, the Kalahari, Ethiopia, India and Antarctica), have led to many shifts in our view of the world's history since its occupation by humans (Goudie, 1984).

The environmental history of the temperate latitudes in the Northern Hemisphere is relatively well established, due to the development and perfection of techniques such as pollen analysis (Flenley, 1979a) and the suitability of the environments for the preservation of fossil evidence. For some parts of the world, notably Western Europe and North America, fairly sophisticated models of environmental change over this period have been developed by Embleton and King (1967) and Hoffman and Knox Jones (1970), respectively.

The elucidation of past environments has become widespread, with studies being conducted in the tropics of Africa (Livingstone, 1967, 1975, 1980; Walker and Flenley, 1979; Crossley *et al.*, 1984; Douglas and Spencer, 1985), South

America (Van der Hammen, 1954; Heusser, 1984; Mercer, 1984; Peeters, 1984), New Zealand (Mildenhall and Pocknall, 1984; Soons, 1984) and Australia (Kershaw, 1971, 1978; Singh *et al.*, 1981; Truswell and Harris, 1982; Firman, 1984). Palynological studies showing climate-vegetation changes in Central Africa have been conducted in East Africa by Van Zinderen Bakker (1962), Coetzee (1967), Livingstone (1967, 1975), Hamilton (1972, 1982), Van Zinderen Bakker and Coetzee (1988) and in South Central Africa by Meadows (1983, 1984a, 1984b, 1985b). The pioneer southern African work, conducted by Van Zinderen Bakker (1955, 1962) in Lesotho and northern Angola, appeared to show that it was possible to correlate late Glacial and Post-Glacial events in the East African Mountains with the European sequence. However, this type of intercontinental correlation has been criticised by Livingstone (1967), who notes that there is no discernible basis for a detailed correlation of either vegetation or climate on a zone-for-zone basis with the established sequence of temperate countries. Nevertheless, marked pollen changes do suggest that during the Holocene the mountainous regions of East Africa were as unstable with respect to vegetation and climate as extra-tropical regions. As in Europe, forest vegetation seems to have been more extensive during parts of the Holocene than it is now.

In this review, environmental and associated biological changes, particularly vegetation changes, which occurred during the Last Glacial Maximum of the Upper Pleistocene (18 000 BP) through to the Holocene sequence and historical times are discussed. A general sketch of environmental changes in southern Africa is given, followed by an outline of the smaller-scale changes of the Karoo environment and the south-western margins of the Karoo.

2.2 EVIDENCE FOR ENVIRONMENTAL CHANGE IN SOUTHERN AFRICA.

Over the past few years much has been written on environmental changes in southern Africa, culminating in the publication of two edited volumes (Klein, 1984b; Vogel, 1984), the extensive review by Tyson (1986) and the comprehensive account of late Quaternary palaeoenvironments by Deacon and Lancaster (1988). In southern Africa, the Quaternary has been studied by three groups of workers: those aligned to the geological sciences, who are interested in the landforms, sedimentary deposits and the different aspects of soil types; the natural scientists or ecologists who are concerned with the general functioning of ecosystems over time; and those concerned with archaeology and the history of human settlement in southern Africa. All need to know how old the deposits are and under what climatic and other environmental conditions they formed. In contrast to the abundance of evidence for environmental changes in the Northern Hemisphere, there are few detailed palynological studies of environmental fluctuations in southern Africa. Due to the paucity of data for the huge expanse of land, the patterns of environmental change are still relatively unclear.

Although southern Africa was not glaciated at any time during the Quaternary period, it did experience long periods of cooler temperatures of approximately 5^0 to 9^0C lower than the present during the glacial periods, when ice sheets expanded at high latitudes and at high altitudes in the lower latitudes. Accompanying the temperature changes, there were marked changes in the rainfall patterns. These global climatic changes between glacials and interglacials may have influenced the composition and distribution of plants and animals on the subcontinent (Deacon, 1983a).

Our current understanding of late Pleistocene and Holocene climates in southern Africa has come largely from analysis of the oxygen-isotope records preserved in deep-sea cores

(Shackleton and Opdyke, 1976) and the Vostok ice core from Antarctica (Jouzel *et al.*, 1987). The oxygen-isotope record measures the contribution of glacial regression melt-waters to the oceans during periods of glacial regression and is a proxy indicator of sea-surface temperatures. The Vostok ice core provides a continuous deuterium record for the past 160 000 years and is interpreted in terms of atmospheric temperature changes. This series provides the most direct support, so far, of the interaction between carbon dioxide, orbital forcing and climate (Genthon *et al.*, 1987). Although these records provide an indication of trends in climatic change, it remains necessary to translate these into the effects on terrestrial ecosystems as a whole and on individual organisms (Deacon and Deacon, 1986). The primary interest has been in gaining an appreciation of the effects of environmental forcing on the environments of southern Africa. With the relatively recent application of pollen analysis and the development of radiocarbon-dating techniques, new light is being shed on the climatic and vegetation history of southern Africa. This evidence has shown that the cool, dry climates of southern Africa prevailed synchronously with the Glacial periods of the Northern Hemisphere (Deacon and Lancaster, 1988).

The geological history of southern Africa during the Quaternary has been characterised by tectonic stability, which followed the Tertiary period of uplift. The main process involved in landform evolution has been erosion rather than deposition. In addition, seasonal climates, aridity and soil pH are not favourable for the preservation of plant and animal fossils. These conditions make the compilation of a terrestrial record of palaeoenvironmental changes for southern Africa a complex task. Early attempts at reconstructing Quaternary palaeoenvironments and their relationships to past climatic conditions were largely in the field of earth sciences and geology. Geological and geomorphological studies are still important, but have now been complemented by an increasing emphasis on

palaeoentological, palynological and stable isotope studies. This has enhanced the resolution of reconstructions and has promoted multidisciplinary studies. The terrestrial record is still patchy and incomplete, but it nevertheless confirms that the scale and timing of the climatic changes in southern Africa were essentially similar to those in other regions of the Southern Hemisphere (Deacon and Lancaster, 1988).

Biological indicators, such as plant and animal fossils, provide some of the clearest evidence for the scale and timing of past climatic changes in the late Quaternary. The effects of climatic forcing on biological communities is readily discernible, but it is more difficult to assess the rate at which change occurred. It should also be remembered that the interaction between plants, animals and climate is a dynamic one, and we cannot expect faunal and floral communities to remain static while the climate is fluctuating. Faunal remains, pollen and charcoal data show that plants and animals do not react to climatic changes as wholly integrated communities, but each taxon or alliance has its own range of tolerance and adjusts accordingly (Deacon and Lancaster, 1988).

The nature, scale and timing of changes in late Quaternary environments, as deduced from field observation, serves the dual purpose of informing on the dynamic changes in biogeographic range and ecosystem history and of providing a test for models of changes in synoptic climates in the subcontinent. A number of climatic models have been proposed to explain regional changes and variations in precipitation. Initial interest in reconstructing past climatic changes in southern Africa was stimulated by the palynological work of Van Zinderen Bakker (1957, 1962) in his reconstruction of glacial/interglacial climates for the African continent as a whole. Climatic models proposed to explain regional changes and variations in rainfall have been refined over the past 25 years and the most recent ones

by Nicholson and Flöhn (1980), Harrison *et al.* (1984), Tyson (1986) and Cockcroft *et al.* (1987) have made more sophisticated use of modern climatic analogues.

The former two examine the movement of the Inter-Tropical Convergence Zone (ITCZ) south of its present position because of a larger extent of continental ice in the northern hemisphere during the Last Glacial Maximum. For southern Africa, their model suggests more vigorous westerlies situated further north than today, but a reduction in precipitation, especially over land, during the Last Glacial Maximum. A variation, proposed by Van Zinderen Bakker (1980; 1982b) and Heine (1982), also assumes strengthening of the circulation pattern, but with stronger trade winds bringing winter rains as far north as the southern Kalahari and summer rainfall over the Kalahari.

The latter two models suggest that the climate of the Last Glacial Maximum was dominated by an enhanced Southern Oscillation*1 that would have brought drier conditions to the summer rainfall region and wetter conditions to the winter rainfall region. Winter rains would have extended to 25^{0} south and inland of present limits. They assume that during periods of low temperatures the Southern Oscillation would have been in a low phase (ie. summer drought in the summer rainfall region) and during periods of higher temperatures the Southern Oscillation would have been in a high phase bringing increased rainfall to the summer rainfall region (Figure 2.1). During a low phase, westerly winds and cyclones would have been drawn northwards, increasing winter rainfall, and during a high phase the opposite would occur, bringing winter drought. The implication is that dry periods in the summer rainfall region should coincide with wet periods in the winter

*1 In the summer rainfall zone, wetter spells are associated with the development of lowered pressure over southern Africa and increases in pressure over the southern Atlantic. In dry spells the converse applies. The development of such circulation patterns appears to be linked to variations in the zonal Walker Circulation, the so-called Southern Oscillation (Deacon and Lancaster, 1988).

rainfall region and vice versa. Although there are differences in the models, they both predict an equatorward shift of the westerlies and winter rains during glacials.Harrison *et al.* (1984) suggest that during the Last Glacial Maximum rainfall was probably similar to or lower than at present in the winter rainfall area, whereas Nicholson and Flöhn (1980) suggest increased winter rain to the north. However, Tyson (1986) and Cockcroft *et al.* (1987) predict higher rainfall from the westerlies both in the present day winter rainfall region and to the north and east.

What little evidence there is from the winter rainfall region, supports Harrison *et al.* (1984). Deposits from

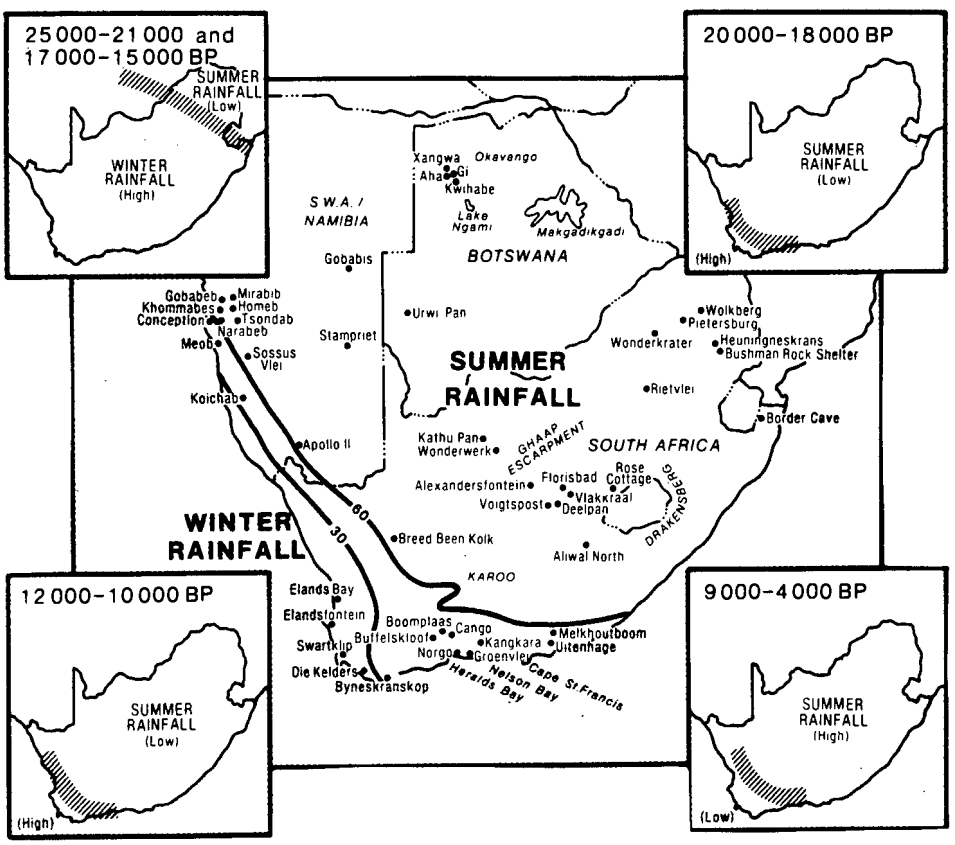

Figure 2.1 Climatic model of the regional rainfall variation in southern Africa. This shows the present-day distribution and summer and winter rainfall regions in southern Africa (isolines give percentage annual rainfall received in summer), together with hypothesised positions of the summer-winter rainfall boundary at different times of the year (After Cockcroft *et al.*, 1987)

Elands Bay Cave (western Cape), dated within 20 000 BP and 11 000 BP, suggest that conditions during the Last Glacial Maximum were were as cold and dry as they were elsewhere in both summer and winter rainfall regions (Butzer, 1979; Parkington, 1986). For both models, it is still necessary to test whether a higher winter rainfall was received north and east of the winter rainfall region, and that the summer and winter rainfall regions were in fact out of phase. In their review Deacon and Lancaster (1988) conclude that the most reliable palaeoenvironmental evidence available in southern Africa does not seem to support a model in which the summer and winter rainfall regions were out of phase in the Last Glacial Cycle. They do not, however, dismiss the models, but reiterate that there is, to date, insufficient convincing evidence to simply accept or reject the models.

Van Zinderen Bakker (1983), from palynological work in East Africa and southern Africa proposed that temperature was the primary factor involved in past climatic changes. Other workers (Coetzee *et al.*, 1983; Butzer, 1984b) favour the idea that both temperature and moisture changes have been fundamental causes of certain manifestations of the climate. The general picture of the late Quaternary period in southern Africa is one of lower temperatures and drier conditions during the glacial periods. In southern Africa, warmer phases and increased precipitation during interglacials may, therefore, have led to the expansion of savanna and woodlands at the expense of semi-arid grasslands and the Karoo. Based on a variety of lines of evidence from river terraces (Vogel, 1982), palynology (Scott, 1982b, 1986; Coetzee, 1983), cave sediments (Deacon, 1979, 1983b; Beaumont, 1986), spring alluvial formations (Butzer, 1984b), peat deposits (Meadows, 1988a), anthropological evidence (Sampson, 1985b), stable isotopes in groundwater (Heaton *et al.*, 1986), fossils of large mammals (Klein, 1984a, 1986) and micromammals (Avery, 1982, 1984), a consistent picture is emerging for the Last Glacial Maximum, dated at about 18 000 BP, of a drier and cooler climate than the present in

the southern African interior. There are, however, some suggestions that the south-western Cape responded somewhat differently to climatic changes in that the Last Glacial Maximum may have been cooler and moister than the present, whereas in the southern Cape the equivalent time appears to have been cooler and drier relative to the present (Scholtz, 1986).

There is evidence in a wide range of environments of markedly wetter conditions immediately after the last Glacial Maximum, between 18 000 and 16 000 BP. At Boomplaas, in the southern Cape, this period was the wettest time of the past 70 000 years (Deacon *et al.*, 1984). Similar conditions were evident at Craigrossie (Scott, 1986) and Aliwal North (Coetzee, 1967) (Figure 2.2). This widespread terminal Pleistocene wetter phase is certainly indicated by the organic sediments which were initiated at Cape Hangklip (Schalke, 1973), Dunedin and Salisbury in the Winterberg (Meadows, Meadows and Sugden, 1987), Kathu Vlei (Butzer, 1984a, 1984b) and Rietvlei in the Transvaal (Scott and Vogel, 1983) around this period.

Although evidence of Quaternary environments is slowly accumulating for southern Africa, not much is known of the primary factors responsible for these fluctuations and changes. Although the Holocene remains enigmatic, the pattern of climatic change appears somewhat more coherent in the light of the organic stratigraphic data, and a moister period commencing between 5 000 and 3 500 BP is strongly indicated (Meadows, 1988a). Deacon (1974), Coetzee (1983), Butzer (1984a), Scott (1984), Meadows (1988a) and Meadows and Meadows (1988), examining radiocarbon dates and palynological evidence during the Holocene, suggest a marked drier phase at 8 000 BP and a return to wetter conditions after about 4 000 BP. Although sequences show variability in temperature between 10 000 and 7 000 BP, the overall picture is one of increasing temperatures (Deacon and Lancaster, 1988).

In the summer rainfall region, pollen analyses from Wonderkrater, Scot, Rietvlei and Moreletta indicate dry and cool conditions between 10 000 and 8 500 BP and somewhat warmer temperatures between 8 500 and 7 500 BP. A second moister phase, during which temperatures were slightly warmer than the present, is indicated by peat initiation or organic deposition dated at around 5 000 and 3 500 BP (Deacon *et al.*, 1984; Butzer and Helgren, 1972; Bousman *et al.*, 1988; Coetzee, 1967; Scott, 1988; Butzer, 1984a, 1984b). Exceptions to this pattern do exist at Wonderkrater (Scott, 1982a), Dunedin (Meadows *et al.*, 1987) and Rietvlei (Scott and Vogel, 1983), where peat accumulation commences earlier, and at Cape Hangklip (Schalke, 1973) and the Little Caledon Valley (Scott, 1986), where there are much later phases of organic sedimentation, suggesting a more complex climatic picture. The last 4 000 years have undergone low level temperature fluctuations around the present-day mean (Vogel, 1983; Deacon and Lancaster, 1988). No consistent pattern is apparent during the Holocene for temperature and rainfall fluctuations in the summer and winter rainfall regions. The implication is that the response of rainfall and temperature values in southern Africa to global temperature changes is complex; global changes, therefore, cannot be used as chronostratigraphic reference points as has been done in the temperate latitudes (Heine, 1982). The most important feature of the last 5 000 to 4 000 years is the fact that, where biological data are available, they show that it was only during this time that modern community alliances were formed.

Holocene environmental fluctuations indicate frequent changes which have no definite pattern. This could be due to the scarcity of chronologically fixed palaeoenvironmental sequences and the lack of evidence over this huge expanse of land, as there are only 27 palynologically studied and dated sites in South Africa (Figure 2.2 and Table 2.1). Meadows

(1988a), in a review of the available data for the Holocene in southern Africa concludes that "quite clearly the most obvious problem is that of a scarcity of data" (p.4).

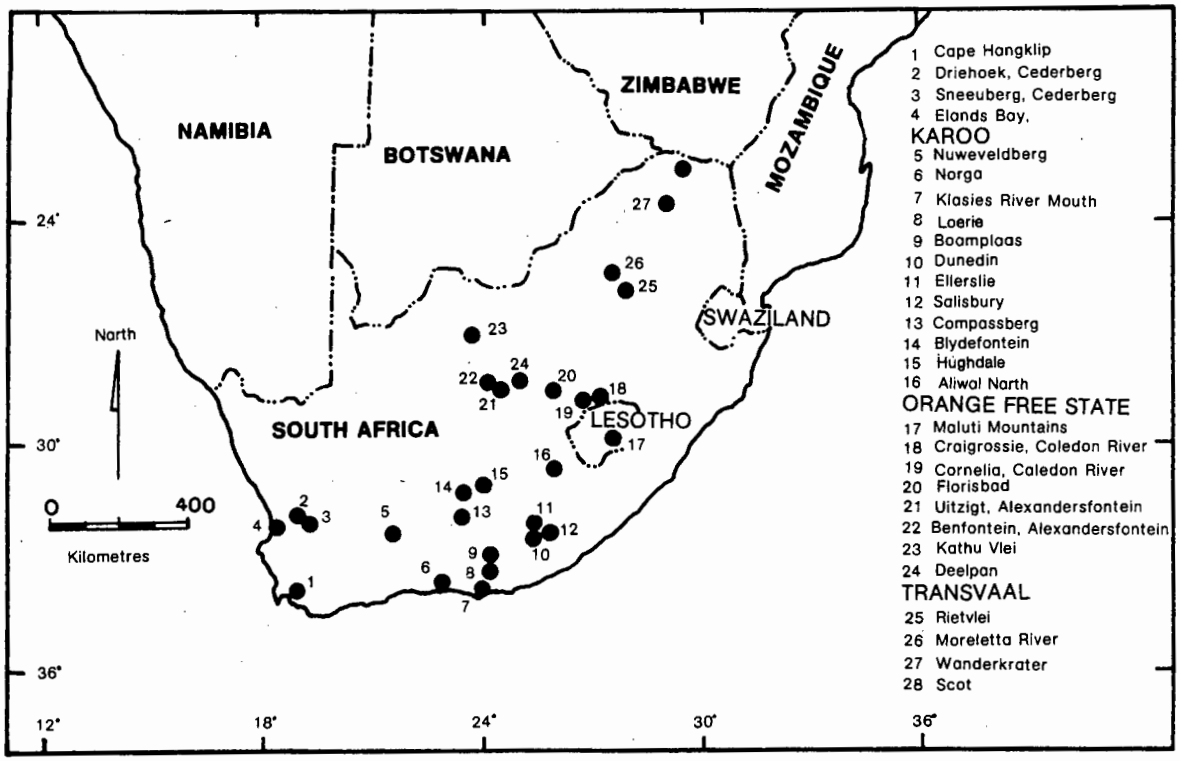

Figure 2.2 Location of radiocarbon-dated deposits and sites where evidence for environmental change in southern Africa have been found (Adapted from Meadows, 1988a).

2.3 PATTERNS OF CHANGE IN THE KAROO AND SW CAPE.

The Karoo region is poorly documented with regard to palaeoenvironmental studies. This is a particular problem in view of the large geographical extent of the biome in relation to the rest of southern Africa, and the apparent sensitivity of the Karroid environment to climatic change (Meadows, 1988a).

	SITE	RADIOCARBON DATE	LAB. NO.	REFERENCE
	1. Cape Hangklip	11 140 ± 65 BP.	Grn-4586	Schalke, 1973.
		1 580 ± 50 BP.	Grn-6359	Schalke, 1973.
*	2. Driehoek Vlei	14 600 ± 290 BP.	Pta-4523	This manuscript.
		10 090 ± 100 BP.	Pta-4759	"
		3 230 ± 70 BP.	Pta-4831	"
*	3. Sneeuberg Vlei	9 640 ± 70 BP.	Pta-4522	"
		3 310 ± 90 BP.	Pta-5007	"
		1 990 ± 80 BP.	Pta-5029	"
*	4. Nuweveldberg	760 ± 50 BP.	Pta-4351	"
	5. Norga	2 980 ± 80 BP.	Pta-2683	Scholtz, 1986.
	6. Groenvlei	6 870 ± 160 BP.	Y-467	Martin, 1968.
		1 905 ± 60 BP.	Y-466	Martin, 1968.
*	7. Boomplaas	17 830 ± 180 BP.	Pta-3283	Deacon, H. et al., 1984.
*	8. Dunedin Vlei	12 500 ± 160 BP.	Pta-4207	Meadows et al., 1987.
		7 880 ± 200 BP.	Wits-1434	"
*	9. Ellerslie Vlei	4 200 ± 60 BP.	Pta-4335	This manuscript.
*	10. Salisbury Vlei	11 800 ± 120 BP.	Pta-4318	Meadows et al., 1987.
*	11. Compassberg	3 590 ± 70 BP.	Pta-4342	This manuscript.
*	12. Blydefontein	7 790 ± 90 BP.	Pta-4461	Bousman et al., 1988.
		5 080 ± 70 BP.	Pta-4273	"
		4 430 ± 70 BP.	Pta-4237	"
		4 260 ± 70 BP.	Pta-4458	"
		4 010 ∓ 60 BP.	Pta-4392	"
		3 290 ± 60 BP.	Pta-4390	"
		2 000 ± 60 BP.	Pta-4465	"
		1 360 ∓ 100 BP.	Pta-4417	"
		290 ± 40 BP.	Pta-4259	"
*	13. Hughdale	3 900 BP.	not quoted	Bousman et al., 1989.
*	14. Aliwal North	12 600 ± 110 BP.	Grn-4011	Coetzee, 1967.
		4 320 ± 110 BP.	I-2108	"
	15. Maluti Mountains	8 020 ± 80 BP.	Pta-751	Van Zinderen Bakker & Werger, 1974.
	16. Craigrossie	10 600 ± 100 BP.	Pta-3682	Scott, 1986.
		600 ± 60 BP.	Pta-3842	"
	17. Cornelia	12 600 ± 110 BP.	Pta-3845	Scott, 1986.
*	18. Florisbad	5 530 ± 110 BP.	Pta-1128	Van Zinderen Bakker, 1957
*	19. Alexandersfontein	4 075 ± 300 BP.	SI-232	Scott, 1976.
*	20. Deelpan	3 890 ± 90 BP.	Pta-3868	Scott, 1988
		2 950 ± 80 BP.	Pta-4183	"
*	21. Voigtspost	6 350 ± 75 BP.	Pta-1520	Horowitz et al., 1978.
		1 220 ± 60 BP.	Pta-1483	"
	22. Rietvlei	10 300 ± 150 BP.	Pta-514	Scott & Vogel, 1983.
		7 130 ± 90 BP.	Pta-2981	"
	23. Moreletta	5 220 ± 55 BP.	Pta-128	Scott, 1984.
		440 ± 40 BP.	Pta-129	"
	24. Wonderkrater	6 330 ± 75 BP.	Pta 2311	Scott, 1982a.
	25. Scot	5 070 ± 60 BP.	Pta-1388	Scott, 1982b.
		3 530 ± 60 BP.	Pta-1392	"
*	26. Kathu Vlei	7 350 ± 90 BP.	Pta-3073	Beaumont et al., 1984.
		6 150 ± 70 BP.	Pta-3545	"
		4 430 ± 60 BP.	Pta-3518	"
		2 990 ± 60 BP.	Pta-3510	"
		1 840 ± 60 BP.	Pta-3504	"
	27. Equus Cave	7 480 ± 80 BP.	Pta-2495	"
		2 390 ± 60 BP.	Pta-2452	"

Table 2.1 Palynologically dated and studied sites in southern Africa. * represents the sites within the semi-arid interior and Karoo Biome.

The greatest problem in conducting palaeoenvironmental investigations in semi-arid environments such as the Karoo, is the scarcity of organic deposits suitable for radiocarbon dating. Establishing an environmental history and hence a vegetation history is dependent on the availability of suitable fossil-bearing deposits. Therefore, the semi-arid regions are problematic, because fragments of vegetation and artifacts are preserved best in moist conditions and the xeric nature of the Karoo makes such conditions rare. Peat deposits do not accumulate freely and, as a consequence, radiocarbon-dated palynological studies are few and far between in such environments, as is apparent from Figure 2.2.

For geomorphological evidence, the situation seems a little more promising (Meadows, 1988a). In the semi-arid environments the "imprints" of the past climates often remain visible for long periods since, following climatic change, geomorphological processes often act slowly enough to preserve previous landforms and sediments. This is not always the case, as geomorphological events of low frequency and high magnitude occasionally occur and may therefore wipe clean the geomorphological slate. Butzer (1984a, 1984b) has investigated many sites within the Karoo and has made enormous advances in the interpretation of fluvial, colluvial and alluvial sediments. The problems of interpreting such evidence are manifold and are reviewed by Meadows (1988a, 1988b). Some of the sites investigated by Butzer (1984b) include Buffelskloof, Boomplaas, Kangkara and Paardeberg in the Karoo *per se*, Alexandersfontein, Klipfontein, Voigtspost, Deelpan and Florisbad on the northern margin of the Karoo, and Elands Bay Cave, Saldanha Bay, Loerie, Die Kelders and Klasies River Mouth in the coastal and winter rainfall areas.

2.3.1 THE TERMINAL PLEISTOCENE (18 000 TO 10 000 BP).

i. The Karoo and Cape Interior.

Little well-dated evidence exists for the period prior to 16 000 BP, which is unfortunate as it represents the period of the Last Glacial Maximum. According to Tyson (1986), Cockcroft *et al.* (1987) and Harrison *et al.* (1984), this period was cooler and drier than the present. Drier conditions have also been reported from Haaskraal (Partridge and Dalby, 1986) and Kathu Pan (Beaumont *et al.*, 1984). Widespread moister and cooler conditions after the retreat of the temperate ice-sheets is, perhaps, one of the stronger late Quaternary environmental signals to emerge in the interior of southern Africa, and elsewhere on the African continent, as indicated by lake-level changes (Street and Grove, 1976).

The period subsequent to the Last Glacial Maximum (15 000 to 10 000 BP) is better documented in the Karoo and indicates a moister period, as shown by the spring discharge at Uitzigt (Butzer, 1984a), formation of a lake at Alexandersfontein (Butzer, 1984b) and fresh-water molluscs at Been Breek Kolk (Kent and Gribnitz, 1985). For the later Pleistocene however, some indications of fluctuating precipitation values are encountered at Alexandersfontein (Butzer, 1984b). The onset of organic sedimentation in vleis and springs both within and around the Karoo certainly support the idea of greater moisture during this time (Meadows, 1988a). Wetter conditions with summer and winter rainfall increases are indicated at Been Breek Kolk (Kent and Gribnitz, 1985), Craigrossie (Scott, 1986), Aliwal North (Coetzee, 1967), Boomplaas (Deacon, H. *et al.*, 1984) and in the Winterberg vleis (Meadows and Meadows, 1988). There is, however, variability in the interior, as there is evidence from Alexandersfontein suggesting a short dry phase at about 13 500 BP between moister phases, whereas dry conditions persisted at Kathu Pan (Scott, 1988). Thackeray (1987), using factor analysis to manipulate fossil micromammal data, documents rising temperatures at several cave sites at the

end of the Pleistocene and soon after the Last Glacial Maximum, as does Coetzee (1967) at Aliwal North.

ii. The south-western Cape.

In the winter rainfall region of the western Cape, cool, dry and windy conditions are evidenced by sediments in the Elands Bay Cave (Butzer, 1979) and by the size of molerats (Klein, 1986). Additional biological and proxy evidence (Van Zinderen Bakker, 1982a; Deacon, 1983b; Werger, 1983; Deacon, H. *et al.*, 1984; Parkington, 1986) substantiates the view that during the Last Glacial Maximum, conditions along the Atlantic shoreline were marked by much stronger westerly wind circulations and temperatures about 5^{0}C lower than the present. The strengthening of wind systems is thought to have been caused by an increase in the temperature gradient between the equator and the poles, but the specific effects at the different latitudes in the southwestern Cape are as yet only partially understood. Deacon, Lancaster and Scott (1984) note however that "palaeosols in the western and southwestern Cape dating to between 25 000 and 15 000 BP are interpreted as indicating conditions at least as moist as during the mid-Holocene " (p. 397). They also refer to the possibility that the winter rainfall area of the western Cape may have been out of phase with the rest of the Cape ecozone (Deacon and Lancaster, 1988) as regards rainfall in the past. The overall conclusions from the various lines of evidence are in agreement with the Parkington (1986) and Deacon (1983a) scenario of a steeper moisture gradient during the Last Glacial Maximum producing winter, cyclonic rainfall over a greater area in the south-western Cape and extending the rainy season at this time.

Biological data from the south-western Cape indicate marked changes in vegetation and small mammals occurring between 16 000 and 14 000 BP. The changes within the larger mammals were slower and postdate 12 000 BP, when several of the Late Pleistocene "giant" bovids became extinct, apparently as a result of the combined effects of environmental change and

the more efficient equipment of the Later Stone Age hunters (Klein, 1984a; Avery, 1982; Deacon, H. *et al.*, 1984). It is therefore thought that climatic conditions were dynamic during the transition from a glacial to interglacial mode of climate, being characterised by major oscillations in available moisture and temperature.

2.3.2 THE HOLOCENE PERIOD.

i. The Karoo and Cape Interior.

During the Holocene, fluctuations in both temperature and moisture occurred, but at a smaller scale than those observed between the glacial and interglacials of the late Pleistocene. Temperature amelioration is indicated throughout the country, but the picture concerning moisture conditions is still unclear for the early Holocene. Sediment studies from Alexandersfontein, Deelpan, the lower Vaal River drainage basin (Butzer, 1984b) and Blydefontein (Bousman *et al.*, 1988, 1989) and the associated pollen analyses from Voigtspost, Deelpan (Scott and Vogel, 1983) and Aliwal North (Coetzee, 1967), indicate two relatively moist phases of differing nature occurring during the early Holocene.

The first moist phase, which was not evident at all sites, dates between 7 700 and 6 300 BP. This phase did not support as complete a vegetation as that which developed during the second phase (3 600 to 1 300 BP), which resulted in extensive soil formation at many of the above-mentioned sites. Few sites of organic deposition demonstrate the onset of sedimentation for the first half of the Holocene and the archaeological hiatus in the interior around this time (Deacon, 1974) perhaps supports the view of a drier period. Temperature estimates from micromammals (Thackeray, 1987) and charcoal analysis (Scholtz, 1987b) from Boomplaas, show the sample dated at 6 400 BP to have been the warmest in the entire sequence, with charcoal analysis suggesting hot, dry summers. Palynological evidence from the Winterberg Mountains on the eastern margin of the Karoo

(Meadows and Meadows, 1988), also indicate warmer, although wetter conditions prevailing at about 8 000 BP. In addition to the biological evidence, Meadows (1988a) records a reduction in the rate of peat accumulation in southern Africa over this period, and concludes that this was due to a period of greater aridity.

The last 4 000 years have been characterised by low level temperature fluctuations around the present day mean, with wetter intervals being recorded between 4 000 and 2 500 BP at Alexandersfontein (Butzer, 1984b), Craigrossie (Scott, 1986) Rietvlei and Voigtspost (Scott, 1976). Bousman *et al.* (1988) document a period of increased moisture availability between 5 000 and 1 000 BP, peaking at 4 000 BP at Blydefontein and Hughdale, when the onset or acceleration of organic sedimentation began. A moister phase, commencing between 5 000 and 3 000 BP and then a return to drier conditions is also documented by Meadows (1988a) from peat accumulation dates.

Therefore, during the second half of the Holocene, the evidence from the Karoo supports the idea of increased available moisture, slightly cooler conditions and a more effective vegetation cover. Towards the present day, marked oscillations in the moisture regime occur, tending towards a drier phase (Butzer, 1984b). Cyclical sedimentation patterns together with palynological evidence from the Sneeuberg Plateau (Bousman *et al.*, 1989) and the Caledon Valley (Scott, 1986) indicate moister conditions and more marked climatic seasonality prevailing from 4 500 to 3 000 BP.

ii. The south-western Cape.

In the south-western Cape (Boomplaas, Nelson Bay Cave, Byneskranskop), the Holocene faunas are dominated by small browsing antelope and ground game, whereas those dating from between 10 000 and 5 000 BP include larger grazers (Klein, 1980). Klein (1980) suggests that this shift implies an

increase in forest and woodland habitats in the second half of the Holocene. Klein and Cruz-Uribe (1987), following on from the extensive palaeoecological analysis of Klein (1972, 1984a), have described grassier vegetation conditions prior to 11 000 BP and drier conditions between 9 000 and 4 000 BP. This accords with an occupational hiatus from 8 000 to 4 000 BP and parallels similar situations elsewhere in southern Africa (Deacon, 1974). Micromammals from Byneskranskop suggest it was relatively dry between 6 400 and 3 900 BP (Avery, 1982). Generally, climatic shifts occurring during the early and mid-Holocene were not as marked as those of the late Pleistocene, with the warmest temperatures occurring between 6 000 and 5 000 BP, when it was generally drier in the interior and moister along the Cape coast (Deacon, J. *et al.*, 1984).

In the southern Cape, rainfall fluctuations of low magnitude and cooler conditions than in the mid-Holocene are suggested by the low incidence of forest taxa and the higher grass component in the last 2 000 years (Martin, 1968). Micromammalian samples from Klasies River Mouth and Byneskranskop indicate that it was wetter after 3 000 and 2 000 BP, respectively and cooler at Die Kelders during the last 2 000 years (Avery, 1982, 1984).

Climatic changes in the late Quaternary induced significant changes in plant and animal distributions, and these in turn affected human habits, particularly with regard to the availability of food resources. The distribution and density of human populations was to a certain extent constrained by the ability of people to cope with changes in the natural productivity of their environments, because prior to the last 2 000 years, agriculture was not practised in southern Africa (Deacon and Lancaster, 1988). The role of human activity becomes increasingly evident in the landscape, particularly during the last few hundred years. The introduction of pastoralism, initially in the western Cape about 1 800 years ago and subsequently further afield

(Deacon, 1974), becomes a major consideration when examining environmental changes during this period. It is inescapable that residual hunter-gatherers and pastoralists left traces at a large number of point locations in the landscape in the period between 1 800 and 300 years ago (Parkington, 1986). It is this evidence which, together with climatic and vegetational evidence, plays a major role in unravelling the environmental history of the Karoo region.

2.4 CONCLUSION.

The last 25 000 years of geological time incorporates the end of the Pleistocene and the Holocene epoch. Although southern Africa was not glaciated during this period, there were significant climatic changes in these latitudes. Globally, the cyclicity of glacials and interglacials has been shown to be a response to orbital perturbations of the earth moving around the sun, as predicted by Milankovitch (Hays, Imbrie and Shackleton, 1976) and the patterning is made more complex by brief warmer and cooler oscillations occurring within the glacials and interglacials respectively. Climatic models have been proposed to explain the variations in the moisture regimes. They suggest an equatorward movement of the winter rains during the Last Glacial Maximum, but reliable palaeoenvironmental evidence is still required to unequivocally support the models of Tyson (1986) and Cockcroft *et al.* (1987), that the summer and winter rainfall regions were, in fact, out of phase.

In the southern Cape and interior, the dry conditions of the Last Glacial Maximum were followed by a period of higher rainfall which lasted until some time after 12 000 BP. Climatic shifts during the Holocene were not as marked as those of the late Pleistocene, with the warmest temperatures occurring between 7 000 and 5 000 BP, when it was generally drier in the Karoo and moister along the Cape coast. There

is evidence of another moister phase from about 5 000 to 2 000 BP in the interior of southern Africa. Additional evidence suggests cooler temperatures in the Cape during the last 2 000 years and rainfall fluctuations of relatively low magnitude throughout the Holocene.

Historical biogeographical implications from the analyses of biological data indicate that modern communities of plant and animal taxa developed only within the last 5 000 years, when human population densities in southern Africa suggest productivity was higher than during the Last Glacial Maximum and Early Holocene (Deacon and Lancaster, 1988). This observation implies that modern climatic patterns, including the degree of seasonality that exists between summer and winter temperatures, rainfall regimes and boundaries between rainfall zones, also date to within the last 5 000 years. If this is the case, then modern climatic analogues may not be appropriate for modelling palaeoclimates in southern Africa for periods older than 5 000 years. It is therefore essential that the palaeoenvironmental data base is enlarged and that biogeographic studies in which environmental changes from a number of different lines of evidence are integrated. These multidisciplinary studies would therefore have greater power to explain past patterns of plant and animal distribution and the climatic conditions that affect sedimentary sequences.

The present day vegetation communities are the product of dynamic biological processes operating over time. This review has shown that climatic changes in the late Quaternary have been a pervasive factor in determining the composition and nature of modern natural plant communities and that modern distributions were achieved only in the last 4 000 - 5 000 years. However, during the last 2 000 years, and particularly since the arrival of European colonists, the natural communities have been considerably modified by landuse practices. These agricultural and settlement patterns have modified and lowered the diversity of

ecosystems and reduced their resilience or ability to adapt to changes, in some ways simulating conditions similar to the Last Glacial Maximum. It is therefore necessary for us to understand how the vegetation and environment in the more sensitive marginal and arid areas has changed, so that we may more effectively and appropriately manage the present environment and prevent further degradation (Sugden and Meadows, in press).

CHAPTER 3

THE STUDY AREAS AND PRESENT ENVIRONMENT

3.1 INTRODUCTION.

The Karoo-Namib Region (Werger, 1978; White, 1983) comprises the extensive arid and semi-arid areas of the south-western part of southern Africa and encompasses a high diversity of climates, landforms, soils and vegetation. This region has been divided into three biomes on the basis of the Summer Aridity Index*2, percentage winter half-year rainfall and life-form mix*3 (Rutherford and Westfall, 1986). These biomes are the Nama-Karoo, Succulent Karoo and Desert Biome (Figure 3.1). This study focuses on the Nama-Karoo Biome and the south-eastern section of the Succulent Karoo Biome, which comprise the Karoo Biome (*sensu* Huntley, 1984). The biome contributes considerably to the gross domestic product and there are important economic motives for a greater comprehension of how Karoo ecosystems operate (Cowling, 1986). Part of this understanding concerns the search for information regarding the way in which the semi-arid areas have responded to climatic and associated environmental changes, which have taken place during the geological past.

The initial problem facing palynological investigations in the Karoo is the selection of suitable sites and sediments from which to extract the palaeoenvironmental evidence.

*2 Summer Aridity Index (SAI) is the sum of the mean precipitation for the four hottest months of the year, taken as a natural logarithm for scaling purposes and subtracted from a constant to ensure ascending values with increasing aridity. This index reflects moisture at a physiologically important time of the year and under conditions of high evaporative demand (Rutherford & Westfall, 1986).

*3 Life-form mix is the morphological expression (eg. form, structure, habit) of the adaptation of organisms to their environment and is determined by general physiognomy (Taylor, 1984).

Pollen is best preserved in anaerobic conditions, and the most obvious sources are lake muds, highly organic soils or peats. Work has however been carried out on deposits such as marine sediments (Rossignol-Strick and Duzer, 1979), forest soils (Dimbleby, 1957), cave sediments (Van Zinderen Bakker, 1982a; Beaumont *et al.*, 1978) and coprolites (Scott and Klein, 1981; Scott, 1987).

The availability of sites is to a large degree controlled by climate. Peat deposits do not accumulate freely under semi-arid or arid conditions and, as a consequence, few pollen diagrams have been produced for the Karoo area. Finding polleniferous sites within the Karoo *per se* is problematic, but is overcome by searching for sites in the higher altitude areas which occur in and around the Karoo Biome. In these upland areas there are vleis or marshes which, because of the more humid and cooler climates at these altitudes, have recently accumulated organic sediments.

The study areas are located along an east-west transect of the Karoo Biome, from the Winterberg on the eastern margin, the Nuweveldberg and Sneeuberg Ranges in the Central Karoo, to the Cederberg Range in the west (Figure 3.2). The Cederberg, which is in the Fynbos Biome (Kruger, 1979), forms the western margin of the Karoo. The boundary of the Karoo Biome is at the eastern foothills of the Cederberg and, therefore, marked changes in climate, and hence vegetation, could affect the distribution of marginal taxa. Vegetation changes will then be reflected in the palynological record, as would fluctuations on the eastern boundary. An overview of the Karoo environment along the east-west transect is given, followed by a detailed account of the prevailing conditions at each of the study areas.

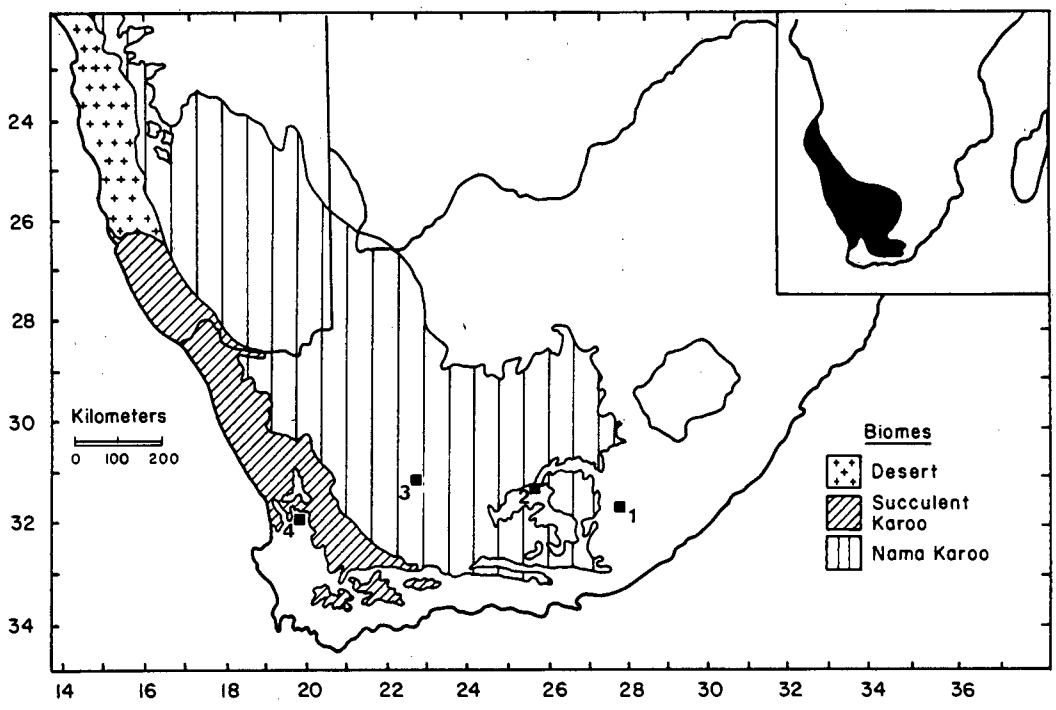

Figure 3.1 The Karoo-Namib Region of southern Africa showing the distribution of the three biomes recognised by Rutherford and Westfall (1986) (After Cowling, 1986). The sites indicated are: 1. Winterberg; 2, Sneeuberg; 3, Nuweveldberg and 4, Cederberg.

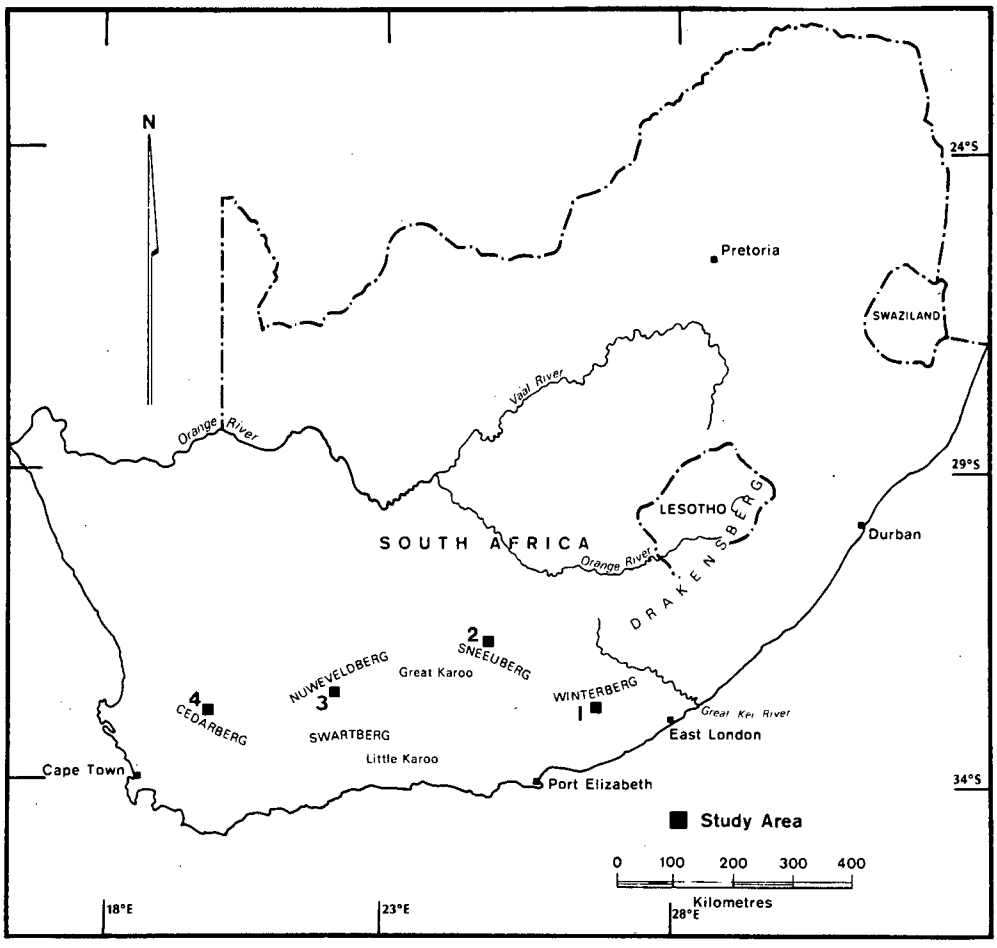

Figure 3.2 Location of the four study areas in southern Africa, forming a west-east transect of the Karoo.

3.2 THE KAROO ENVIRONMENT.

3.2.1 INTRODUCTION.

The Khoisan meaning of the word "Karoo" is "dry land", which is appropriate for this extensive semi-arid area in which the vegetation displays many xeromorphic features (Hilton-Taylor and Moll, 1986). Geologically and climatically, the Karoo is complex and this renders contemporary floristic and geomorphological conditions highly variable. Physiographically, lower-lying areas lie to the south of the Great Escarpment and include the Great Karoo, Little Karoo, Robertson Karoo and Tanqua Karoo. North of the Great Escarpment, which incorporates the Roggeveldberg, Nuweveldberg, Sneeuberg, Winterberg, Amatole and Drakensberg Mountains, the extensive peneplain of the Upper Karoo is found, with its vast undulating plains interrupted by occasional residual mountains. Much of the geology of this biome is dominated by sedimentary rocks of the Karoo Sequence. Deposits of the Cape Supergroup (Bokkeveld and Witteberg Group) occur in the south-west (Visser, 1986).

Floristically, the vegetation varies along the moisture gradient from east to west, becoming more sparse and open as one progresses westwards. The flora of the Nama-Karoo is dominated by Asteraceae, Mesembryanthemaceae (western and southern regions), Poaceae (eastern region), Aizoaceae and Scrophulariaceae (Werger, 1978). A feature of the vegetation is the dominance of dwarf and low succulent shrubs in the winter rainfall region, progressing to dwarf deciduous shrubs where succulents are less conspicuous, in the Central Karoo. Grasses are common throughout and may dominate, depending on the soil, rainfall and grazing intensity.

3.2.2 GEOLOGY AND SOILS.

The Mesozoic Great Karoo Basin (du Toit, 1954) underlies most of the Karoo Biome. This area is comprised

predominantly of sedimentary rocks of the Beaufort Series of the Karoo Supergroup. The Beaufort shales and sandstones have been intruded by dolerite sheets, dykes and sills. The resistant horizontally-disposed Karoo beds, forming the summits of the escarpment are thought to be remnants of the early Tertiary surface (King, 1951).

Beds of the Beaufort Group underlie the greater part of the Karoo region and cover the Central basin. During the Jurassic this basin was intruded by dolerites, which influenced both the structure and lithology of the beds. The dolerite intrusions, of the same age as the lavas of the Drakensberg Group, are scattered in the beds of the Beaufort Group. They give rise to the uneven topography, as they are resistant to weathering and show positive landforms. Mesas, buttes and sharp ridges therefore occur and are characteristic of the Karoo landscape. Centuries of spheroidal weathering of these volcanic intrusions has given rise to characteristic domes and boulders. The dolerite is a dark-coloured, fine to medium crystalline rock-type, which consists primarily of plagioclase and pyroxene (Visser, 1986).

Generally the soils derived from the sedimentary rocks are fertile and relatively deep in the lowlands and valleys. The landscape is, however, susceptible to both water and wind erosion, with sheet, rill and gully erosion being prominent, particularly in the eastern Karoo (Visser, 1986). Duplex soils (Ellis and Lambrechts, 1986) occur in the higher rainfall areas of the Karoo, where the mean annual precipitation is greater than 300mm, such as along the Great Escarpment. The parent materials are mainly Karoo System shales or shale-derived pedisediments from the Karoo Sequence. On the northern plateau undifferentiated soils occur. The most common are the duplex soils, in which the A horizons are leached and have low infiltration capacities and the B horizons are in a dispersed condition (Ellis and Lambrechts, 1986). The low infiltration rate and low free

iron content in the topsoil, together with the action of falling raindrops, cause dispersion and a breakdown of soil aggregates at the surface, which leads to surface sealing (Shainberg and Letey, 1984). The vulnerability of these soils to erosion is accentuated by overgrazing and mismanagement of the sparse Karroid vegetation.

The initial stages of soil erosion include the formation of bare patches which can be seen throughout the Karoo and are usually the result of stripping the orthic-A horizon (Roux and Opperman, 1986). The A horizon is usually a sandy loam which supports a cover of grass, bush or a combination of the two. With the removal of the A horizon, the B horizon dries out and compacts. It is then only able to support a limited number of species and the succulent *Ruschia ferox* frequently becomes dominant. Erosion also affects the ability of seedlings to become established and mechanical means are often required to break this cycle (Hallward, 1987).

3.2.3 VLEI ENVIRONMENTS.

Palynological analyses in the temperate latitudes are usually undertaken using peat samples from marshes or bogs. The term "peat" has been avoided in the context of this study, as these sediments, and this includes all sediments in the Karoo Biome, have an organic content of less than 20% and thus do not fit the definition given by Moore and Bellamy (1974). The definition of peat varies from author to author and may be confused with an organic soil or a lacustrine deposit. Peat deposits are an accumulation of organic detritus, predominantly of plant origin, which have developed in situations where the rate of production of organic matter by a plant community exceeds the combined rates of plant respiration, herbivore consumption and microbial decomposition. In this study the deposits in the vleis are termed organic sediments and it is the topographic

position, hydrology or geomorphology which determines whether these vleis are comparable to peat bogs.

In order for deposits or vleis to develop, certain general climatic and hydrological criteria have to be met (Figure 3.3). The accumulation of vlei sediments is usually associated with cool, moist climates where the decomposition of organic debris is retarded and hydrological conditions entail permanent waterlogging and acidity. Topography is an additional controlling factor, since peat may achieve greater depths and develop at a faster rate in valley-bottom situations or in constricted valleys, such as those in the Winterberg. The organic sediments within these vleis should therefore be mainly autochthonous, consisting of remains of the vegetation that once covered the place where the sample is recovered (Faegri and Iversen, 1975), although the clastic sediments will be allochthonous.

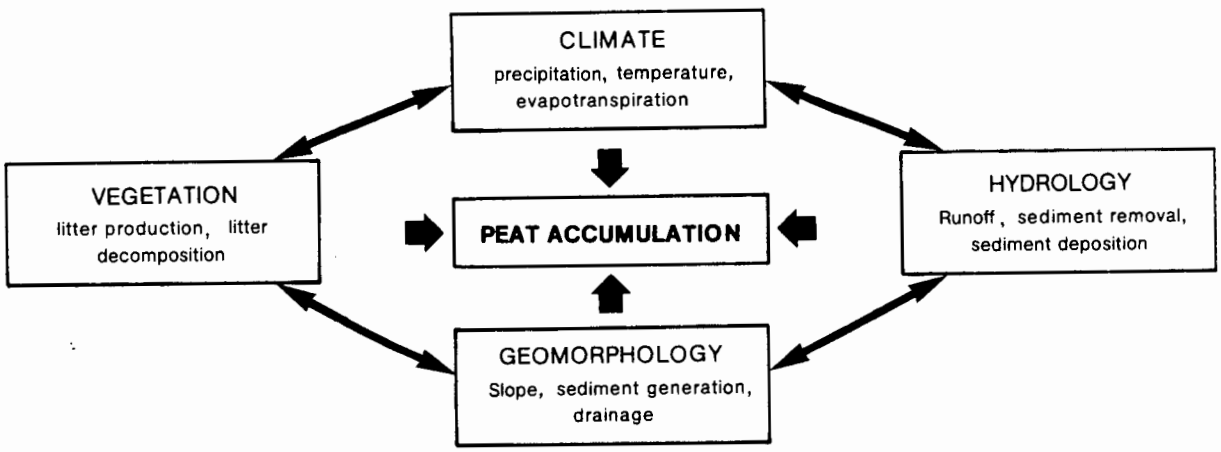

Figure 3.3 Environmental controls on peat accumulation (After Meadows, 1988a).

Vleis within the Karoo and semi-arid areas of southern Africa are similar with regard to morphology and sediment characteristics. They are therefore useful in comparative studies for the interpretation of past environments, particularly with regard to geomorphological processes (Meadows, 1988b). With regard to morphology, all of these vleis seem to follow a characteristic pattern, being broader

at the headwaters and mid-stream, and narrower downstream, where dykes obstruct streamflow.

Within the vleis, the sediments are distributed in a particular pattern similar to that seen in the deposition of sediment load from a river into a dam (Weaver, 1979). The coarser sandy material accumulates along the edge or "washbelt", whereas the finer clay sediments accumulate in the central seepage area. These sediment distribution patterns appear to be present in the vleis investigated. Vleis are found within a wide range of rainfall regimes. This is apparent from the variable regimes from which the four vleis for this particular study have been selected. Climatic change and the changes in rainfall regimes must therefore be considerable to affect overall vlei formation and development, although a more sensitive indicator of prevailing conditions would be the stratigraphy of the sediments that accumulate in the vlei.

The most popular theory of vlei or peat bog development is the "Phasic Theory", proposed by Barber (1981) for temperate latitudes. Vleis in the drier areas of southern Africa are not thought to develop in this way, as soil erosion and low vegetation cover usually influences the sediment input to the vlei. The vleis in the semi-arid areas of the Karoo consist of both colluvial and alluvial sediments and were probably formed by a series of "cut and fill" phases as described by Mäckel (1974). During dry periods, when vegetation cover is reduced, more sediment is transported from the upper reaches of the catchment, resulting in a net removal of sediment from the region and a "cut" in the vlei itself. During moister periods, when vegetation is denser, the sediment is trapped in the vlei, and organic matter accumulates.

With regard to hydrological constraints, the central Karoo represents one of the regions where an absolute limit to the total economically exploitable surface water resources is

foreseen (Görgens and Hughes, 1986). Furthermore, the typical characteristics of semi-arid and arid regions, such as large spatial and temporal variability of rainfall, high temperatures, shallow erodable upland soils, sparse vegetation and large channel losses, dictate a rather tenuous hydrological equilibrium in the Karoo catchments. Görgens and Hughes (1982) cite the proportion of runoff as a percentage of rainfall input to be as low as 4.75% in the Karoo, compared to the humid east of southern Africa, where values may be as high as 30% (Braune and Wessels, 1980). These mean runoff values conceal a marked variability and therefore the coefficient of variation should be considered. A number of factors, particularly land-use, play an important role in runoff generation.

It may be concluded that the geomorphology and hydrology of the Karoo is dominated by a variable rainfall regime, which is acting on catchment surfaces whose vegetation is affected by variable land-use practices and rainfall. This leads to complex shifts in the erosional-depositional balance of the catchments and vleis, and makes the interpretation of palaeoenvironmental data obtained from accumulated sediments and soils hazardous (Meadows, 1988b). Nevertheless, sedimentological analyses, radiocarbon dating and a closer examination of these sediments enables a valuable amount of palaeogeomorphological information to be obtained from these sediment deposits.

3.2.4 CLIMATE.

Climate is an important controlling factor with regard to palynological studies, as it is the main determinant in bog formation and controls the prevailing vegetation. The climate of the Karoo is notable for extremes in temperature and variability in the amount and timing of rainfall (Figure 3.4). Although this region is within the Warm Temperate Zone (Schulze, 1979), Schumann (1949) recognised three climatic regions in the Karoo, characterised in terms

of rainfall seasonality viz: summer rain, even rainfall and winter rain. As little as 61mm falls per annum at Port Nolloth in the winter rainfall Karoo in the west and increases eastwards to 254mm at Victoria West, 346mm at Graaff Reinet and 560mm at Queenstown in the summer rainfall area (Cowling, 1986). Linked to the westward decline in annual precipitation is a decrease in the reliability of precipitation (Schulze and McGee, 1978). Microclimatic conditions are are also important, but are discussed within the regional context.

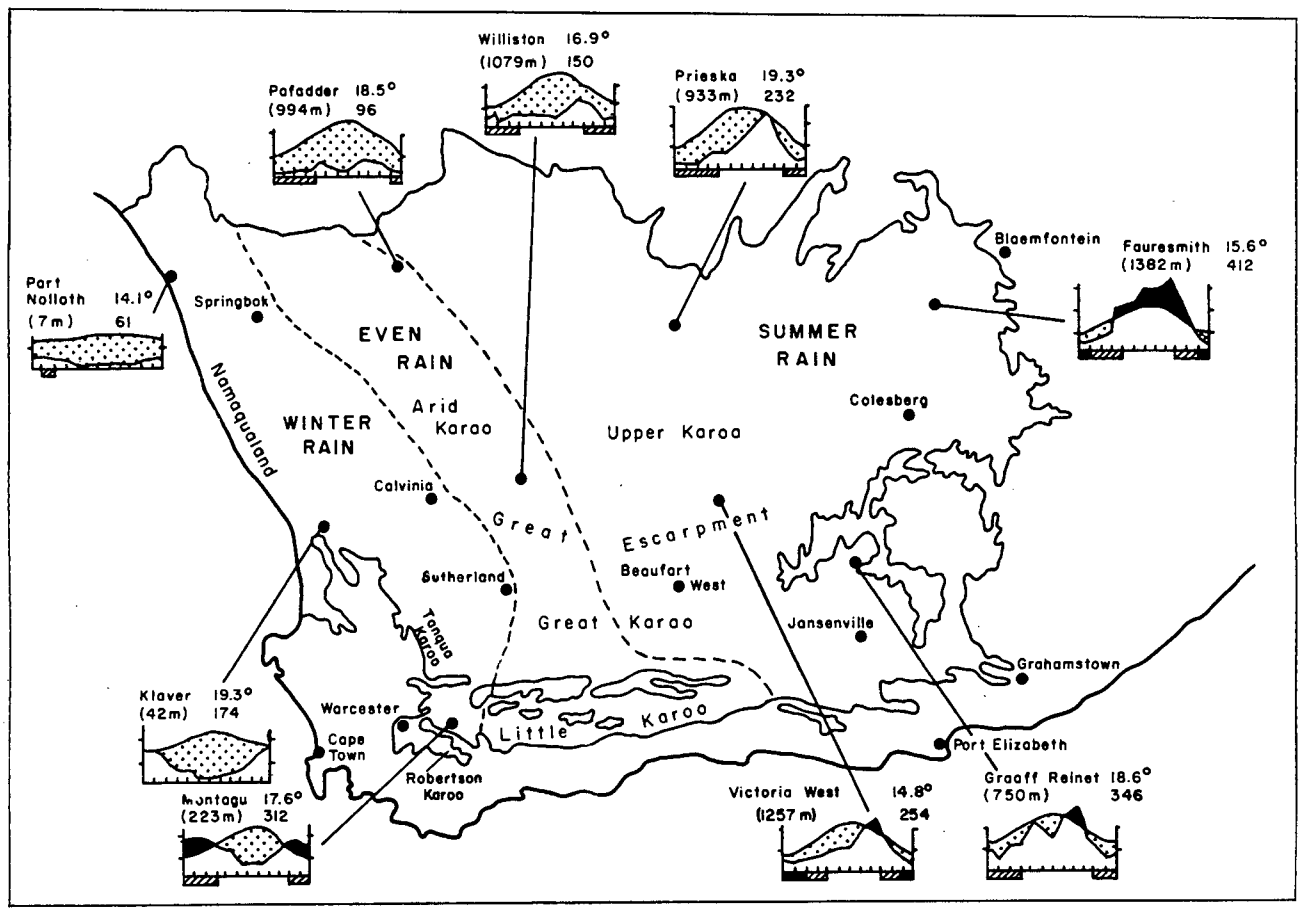

Figure 3.4 The Karoo Biome, showing the climate, topography and principal locations. The moisture gradient from west to east is apparent (After Cowling, 1986).

3.2.5 VEGETATION.

The vegetation of the Central Karoo is dominated by a mixed grass/shrub component, representing the transition from the western shrubveld to the eastern grasslands. The Karoo

flora is characterised by the strong development of the families Asteraceae, Mesembryanthemaceae (western and southern region), Poaceae (particularly Stipeae), Aizoaceae, Liliaceae and Scrophulariaceae (Werger, 1978). Woody dwarf shrubs occur over wide areas, particularly in two growth forms: dwarf shrubs with small, ericoid or finely dissected, sometimes strongly rolled leaves with hairs or a strongly xeromorphic structure; and stem and leaf succulents. The former growth form is widespread among the Asteraceae, while succulents occur in numerous families, perhaps most commonly in Mesembryanthemaceae, Euphorbiaceae, Crassulaceae, Asclepiadaceae and Liliaceae. Many species are not restricted to one domain, but are widespread (Werger, 1978).

The low rainfall regime of the Central Karoo is characterised by stochastic inputs and is the major selective determinant of morphological, physiological and life history traits of the semi-arid Karoo region (Westoby, 1980). Rain, falling at different times of the year and occurring as both small and large events, affects plant species differentially in terms of growth rate, growth form, reproduction and establishment. In the eastern Karoo, substantial spring and summer rains favour the growth and establishment of perennial grasses, whereas autumn, winter and late spring rains favour shrubs (Roux, 1966). Similarly, the growth of annuals with varying temperature requirements for germination and photosynthesis, will be determined by the timing and length of periods of high soil moisture. Both prolonged droughts and a series of unusually high rainfall events will leave their stamp on the composition of the vegetation years or even decades after these rare occurrences (Westoby, 1980). Typical Karoo veld, therefore, comprises a variety of different growth forms, whose persistence is determined by the physiological and demographic responses to stochastic moisture inputs. This indeterminancy has important implications for system dynamics and grazing management (Cowling, 1986).

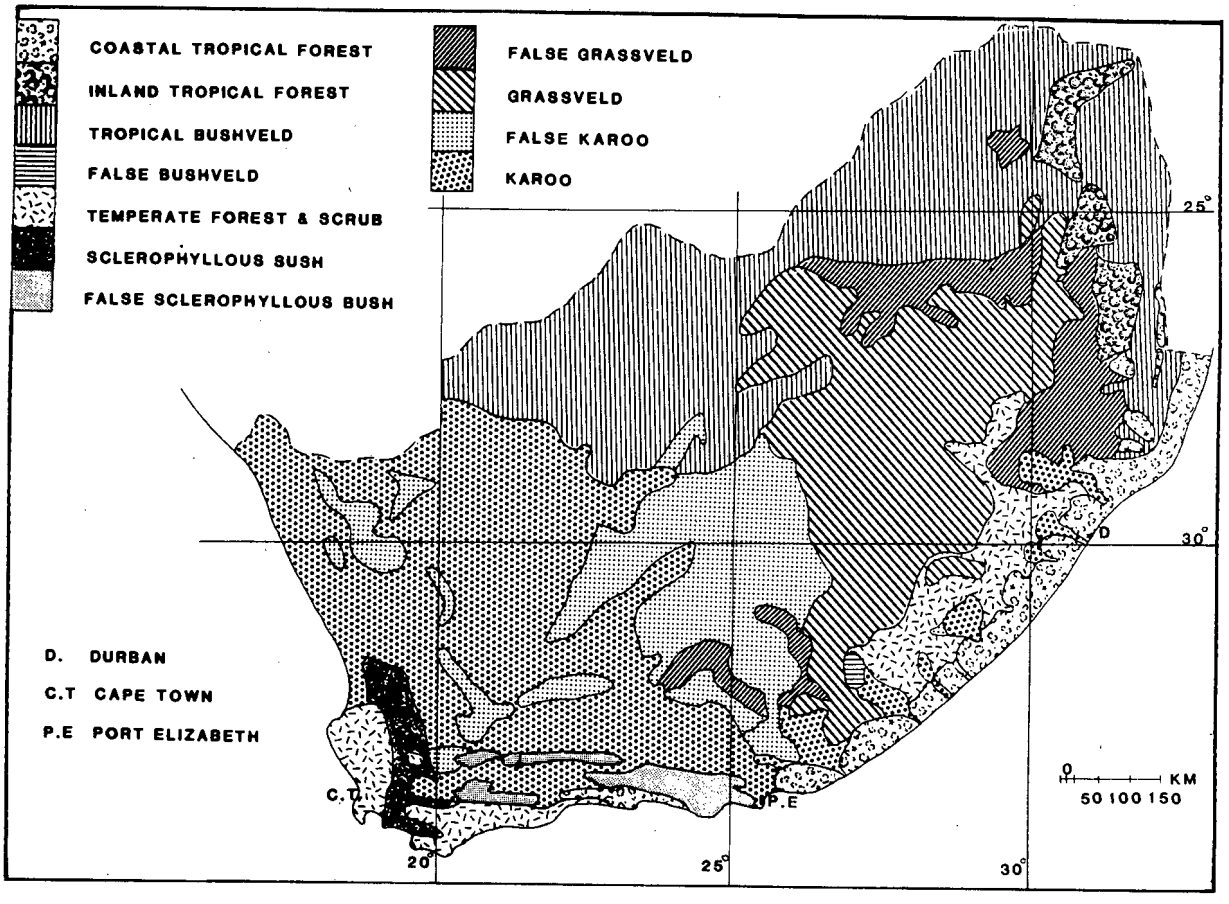

Figure 3.5 A simplified version of Acocks' Veld Types map of South Africa, drawn from the 1:1 500 000 scale map (After Moll, 1988).

A number of classification systems for the large Karoo-Namib region have been used (Acocks, 1953; Monod, 1957; Aubreville, 1975; White, 1983; Rutherford and Westfall, 1986). For the purpose of this study, Whites (1983) phytochorial classification is used to place the diagnostic features of the different vegetation types into the continental context. However, when investigating the vegetation on a local scale, it is more appropriate to have smaller vegetation groups. Therefore, White's (1983) classification is used in conjunction with Acocks' veld types (1953). Figure 3.5 is a vegetation map of southern Africa, showing these veld types. Acocks defines a veld type as "a unit of vegetation whose range of variation is small enough to permit the whole of it to have the same

farming potentialities" (p.1). This definition has led to the grouping and separation of vegetation assemblages which, some may argue, are not valid. For practical purposes and the need for uniformity study, Acocks' veld types are used in the regional descriptions.

i. Capensis Region.

Fynbos taxa of the Capensis Region are strongly represented in the Eastern Cape and western Karoo, particularly on the infertile sandy soils derived from Cape Supergroup rocks. The vegetation consists principally of fynbos, a broad category of diverse evergreen sclerophyllous shrublands comprising Acocks' veld types 47 (Coastal Macchia), 69 (Macchia) and 70 (False Macchia). It also includes two transitional veld types, coastal Renosterbosveld (veld type 46) and Strandveld (veld type 34), that contain a mixture of Cape and other floristic elements (Taylor, 1980). Fynbos is a species-rich vegetation type confined to sites of infertile soils, which receive most of their rainfall in the winter months. It is thought that the original vegetation of the coastal lowlands was shrub grassland, with thicket patches, including taxa of tropical Cape and karroid affinities (Cowling, 1983; Cowling, Pierce and Moll, 1986).

ii. Karoo-Namib Region.

Succulent and dwarf shrublands of the Karoo-Namib region extend down the dry river valleys from the arid interior. This region comprises dwarf shrublands of the arid and semi-arid parts of southern Africa. The Karoo extends in a continuous belt from the west coast, across the Cape Province to the Drakensberg and Winterberg escarpments. The eastern section is thought to have been grasslands in the past (Acocks, 1953; Werger, 1978), but due to overgrazing and mismanagement has been converted to a secondary Karoo dwarf shrubland.

Although White (1983) classifies the entire Karoo as Dwarf Karoo Shrubland, Acocks (1953) recognises a number of

different veld types. According to Acocks' classification, the semi-arid Karoo plains are classified as Karroid Brokenveld (veld type 26) and characterised by dwarf shrubs and succulents in the west. Karroid Merxmuellera Mountainveld (veld type 60) covers most of the high mountains of the False Karoo and Central Upper Karoo. The natural dominant in the rocky sandstone and shale areas is *Merxmuellera disticha* and *M. stricta*, whereas in the dolerite areas *Themeda triandra*, *Tetrachne dregei* and *Ehrharta calycina* are the natural dominants (Acocks, 1953). These grasslands are most abundant on the warmer northern aspects. In many parts, the Merxmuellera Mountainveld has been disturbed and is transitional to Grassy Mountain Scrub or is being invaded by Karroid Brokenveld (Acocks, 1953) and is referred to as Merxmuellera Mountainveld replaced by Karoo (veld type 42). On the southern aspects of these mountainous areas there is a dense, grassy scrub which is classified as Upper Karoo (veld type 27) and False Upper Karoo (veld type 36) on the eastern plateau (Acocks, 1953). The Upper Karoo plains and mountain slopes are covered by grasses of the "white type" and represented by *Aristida congesta*, *A. adscensionis* and *Eragrostis lehmanniana*.

iii. Afromontane Region.

Increased latitude compensates for altitude and, therefore, Afromontane elements are found at sea level in the south-eastern Cape, and mountain forests are entirely composed of Afromontane species (White, 1983). The Afromontane Region is an archipelago of mountain islands which extends from Somalia in the north to the Cape Peninsula in the south. The Afromontane element is divided into a Subalpine and Alpine Belt. The Subalpine belt is restricted to the Cape and Natal Drakensberg, the Amatole and Winterberg mountains. Its presence in other areas in southern Africa is doubted, with the exception of Malawi (Meadows, 1984a). The dominant vegetation types include grasslands, forests and fynbos. Sourveld grasslands dominate on the Winterberg, with *Helichrysum argyrophyllum* communities becoming established

as a result of the destruction of the grassland (Acocks, 1953). The subalpine forest is the climax community (Story, 1952) and occurs sporadically on south-facing mountain slopes. Afromontane Forest patches are common on the south-facing slopes of the Winterberg and Amatole Mountains.

iv. Tongoland - Pondoland Region.

Forest and thicket (Moll and White, 1978) enter the south-eastern Cape along the coast and penetrate up the river valleys (Cowling, 1983). It consists of a complex mosaic of forest in a matrix of secondary and wooded grassland. The evergreen and semi-evergreen bushland and forest occurs on the Winterberg, where rainfall is high enough to support the Afromontane forest, whereas the thicket occurs on the drier coastal plains.

According to Acocks (1953), large tracts of the Central Upper Karoo have become invaded by species of the arid Karoo. The Karoo vegetation now contains a mixture of species from both veld types. To a large extent the "invasion" of arid Karoo species into this area merely means an increase in their abundance rather than a real invasion (Werger, 1978).

3.3 THE WINTERBERG RANGE.

3.3.1 INTRODUCTION.

Ellerslie Vlei, on the Winterberg Range, was chosen as the study site on the eastern margin of the Karoo. Two vleis, Dunedin and Salisbury, had previously been investigated and yielded interesting results (Meadows and Meadows, 1988). Ellerslie, on the Elandsberg Plateau has been investigated to ensure that all sites in this study are examined using uniform techniques. Environmental conditions and vegetation types occurring in close proximity to the study area are

outlined and the Winterberg vegetation is then placed in a regional framework.

A feature of this site is that it is in the convergence zone of several vegetation types and would therefore probably show vegetation changes in response to environmental fluctuations. The south-eastern Cape region forms a major climatic, topographic and geological transition zone and is consequently a focus of convergence for four phytochoria viz. the Cape, Afromontane, Karoo-Namib and Tongoland-Pondoland elements (Werger, 1978; Gibbs Russell and Robinson, 1981; White, 1983; Cowling, 1983). The transition zones between the phytochoria therefore provide natural laboratories in which to study the ecological factors governing biogeographic delimitation, which is important in determining vegetation histories (Cowling, 1983). The Winterberg site, which forms the extreme eastern margin of the Karoo Biome (Figure 3.6) is accordingly, of importance in detecting any previous expansion of what is today known as the Karoo.

3.3.2 LOCATION AND TOPOGRAPHY.

The Winterberg Plateau forms the extreme south-easterly section of the Great Escarpment, separating the coastal plain from the interior plateau of the Karoo. The Winterberg Range comprises a number of peaks, namely Elandsberg, which is the highest in the area (2 017m), the three Hogsback ridges (1 939m), Gaikaskop (1 963m) and Katberg (1 832m). The summits of this escarpment are remnants of the early Tertiary "African" surface (King and King, 1959) and represent some of the original surfaces. The resistance of the residual peaks is attributed to the dolerite dykes and sills, which overlay the Beaufort sediments (King, 1951).

The Winterberg Range trends in a north-east to south-west direction for almost 80km and is dissected by a number of

strongly flowing streams running either from the east into the Fish River or from the west into the Keiskamma River (Figure 3.7). The south-eastern slopes rise sharply from the coastal plain to heights of 1 500m and then give way to undulating country, which rises to a maximum of 2 372m. The leeward slope levels out to form the drier Karoo plains. Ellerslie Vlei (Plate 3.1) is situated on this gentle leeward slope, on Ellerslie Farm (32°26'30"S; 26°45'15"E). This vlei is part of a much larger marshland, situated on a gently undulating highland area at 1 400m and is at the headwaters of the Esk River.

3.3.3 GEOLOGY AND SOILS.

i. Local geology.

The Winterberg Range is situated on the south-eastern margin of the Great Karoo Basin (du Toit, 1954), which is comprised predominantly of sedimentary rocks of the Beaufort Series from the Karoo Supergroup. The Beaufort Series dips uniformly towards the north and is divided into three groups. The Lower Beaufort Group (Upper Permian/Lower Triassic age) occurs in a narrow band above 1 616m. These coarse-grained sandstones have been intruded by dolerite. The Upper Beaufort (Lower Triassic) occurs above 1 920m and is limited to peaks, which are largely composed of dolerite. Resistant dolerite columnar structures are noted on the summits of the Elandsberg, Hogsback and Katberg. Exposed sandstone bedding on cliffs and quarries display minor unconformities where the sandstone has been truncated by underlying shales. This evidence, together with the lenses of clayey conglomerates and shales is indicative of previous deposition in seasonal lakes (du Toit, 1954).

ii. Superficial deposits and vleis.

The leeward side of the Winterberg plateau is characterised by an undulating landscape, with many streams. The path of these streams has, in many cases been obstructed by dolerite

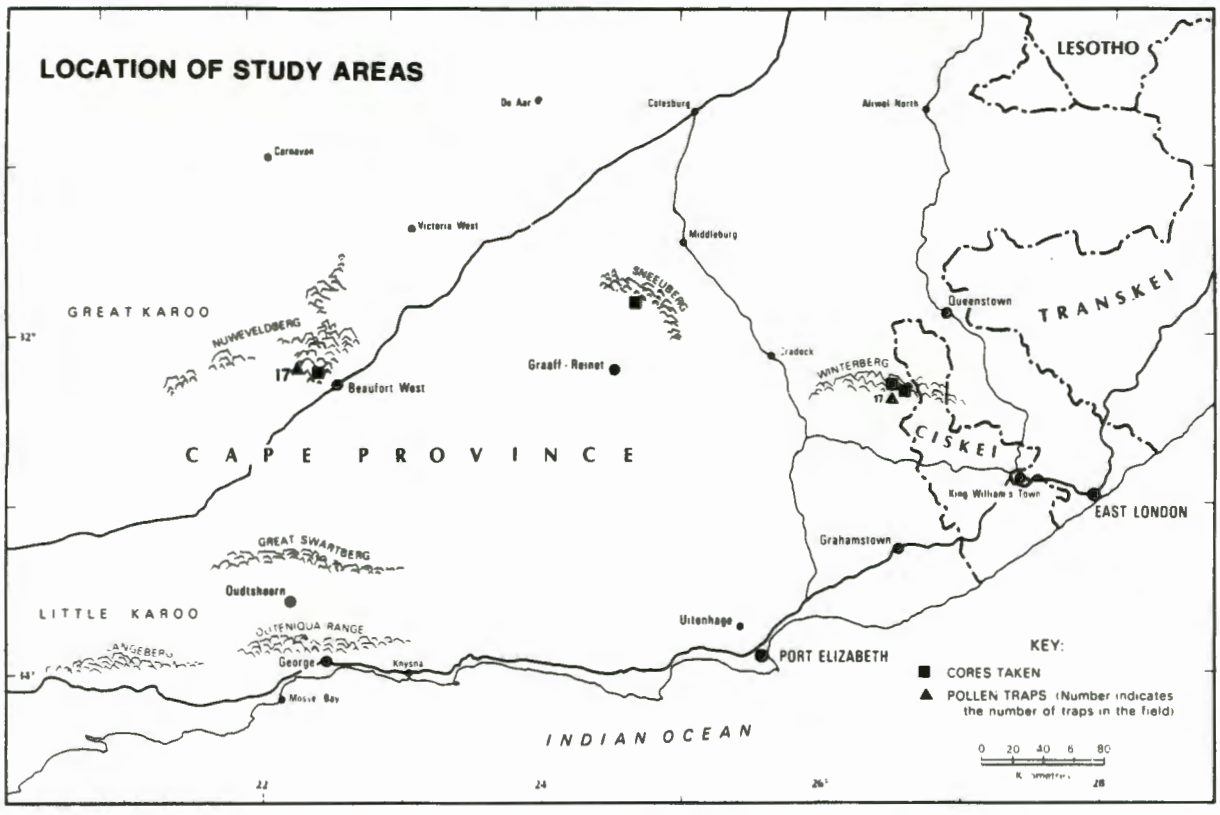

Figure 3.6 Location of the mountainous areas in the Eastern Cape, particularly the Winterberg, Sneeuberg and Nuweveldberg Ranges.

Plate 3.1 Ellerslie Vlei on the Winterberg Range. Sourveld grasslands cover the surrounding hills.

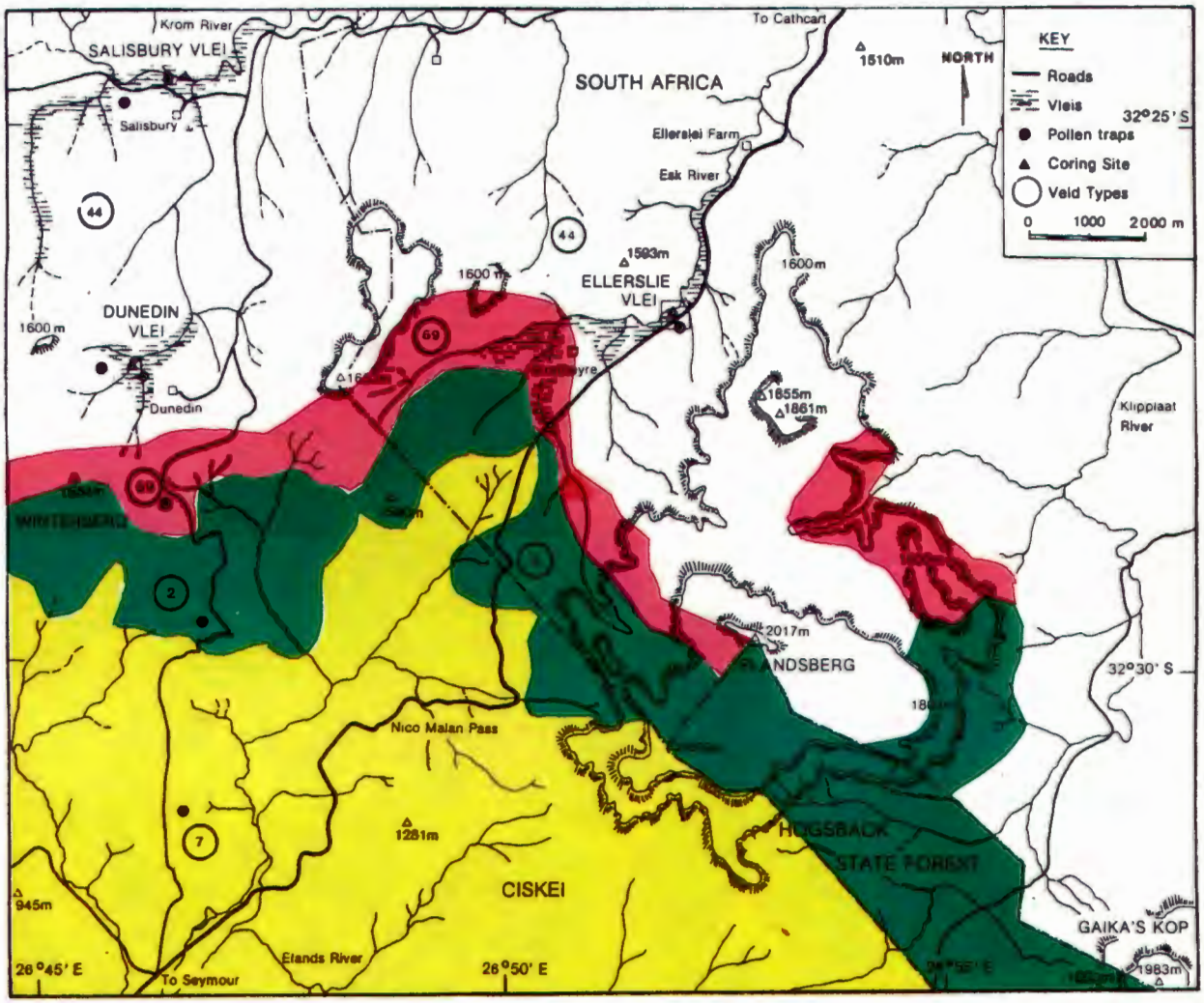

Figure 3.7 The Winterberg Range and the location of Ellerlie Vlei. The two vleis investigated by Meadows and Meaadows (1988) are shown. The veld types indicated are: 2, Montane Forest; 7, Eastern Cape Thornveld; 44, Dohne Sourveld and 69, Macchia.

dykes, thus impeding their flow and generating conditions suitable for the accumulation of organic sediments. The black organic sediments from Ellerslie Vlei are similar to those found at Dunedin and Salisbury Vleis, which are approximately 15km to the west (Meadows and Meadows, 1988). The sediments consist of a thick layer of black fibrous organic sediment, which overlies fine black amorphous organic sediment. The basal sediments are coarse, partially weathered fragments of the underlying bedrock.

iii. Soils.

The major soil types conform closely to the geological substrate, therefore this region is characterised by several soil types. Clayey soils are derived from the Beaufort Series; uniform dark brown clays with a poorly developed B horizon are derived from dolerite parent material; and on the sedimentary rocks, podzolised soils have developed due to the high rainfall and associated leaching in this area (Childs, 1971). Generally, the soils from sedimentary rocks may be divided into shallow grey loams with ferruginous concretions from a few centimetres to a few metres below the surface; grey loams which form on clay and are deeper, but deficient in available nutrients; and finally yellowish-brown sandy loams which form on sandstone. These three make up more than half of the soils in the area (Killick, 1978). The dolerite soils, comprising about one third of the area, consist of black clays 30 to 60cm deep and deep red clays (up to 2m, which are chocolate when virgin and red after cultivation. Finally, black, well-developed clays form on the undulating plains (Killick, 1978). In the valleys, a relatively fertile,coarse, light loam develops. The soils of the north-western gentle slopes are relatively thick, well-developed and fertile as compared to the thin, poorly developed soils of the south-eastern slopes. The steeper slopes give rise to sheet wash and result in the thin, nutrient deficient soils of the eastern slope.

3.3.4 CLIMATE.

The climate ranges from a warm temperate perhumid forest climate on the southern mountain slopes to a subhumid forest climate in the north (Schulze, 1979). This area is in the convergence zone of climatic belts and experiences variable conditions. The two climatic influences are the dry adiabatically heated air mass descending from the inland plateau and the cool air mass from the Indian Ocean. The Winterberg is also affected by the eastward moving anticyclones and low pressure cells which have their centres south of the country and play an important part in determining weather conditions of the southern and south-western Cape. These low pressure cells are more frequent in spring and autumn, whereas adiabatic and orographic rainfall dominates in the summer months (Tyson, 1986).

This mountain range receives much orographic precipitation and snow occurs from as early as April. This area has a summer rainfall maximum, with brief intense summer thunderstorms, much of which is lost as runoff or evaporation. The snow is usually associated with the eastward moving depressions and is of greater value than summer precipitation, as it is trapped in the vegetation and infiltrates the soil. The Winterberg has a mean annual rainfall of 1 000mm, which drops sharply to 500mm on the plains. Temperatures are subject to large seasonal variation and may vary from 30^{o}C in the summer to below 0^{o}C in the winter. The climatic difference between the coastal plains and uplands of the Winterberg plateau is dramatic and is expressed in the vegetation gradient on the eastern slopes of this range.

3.3.5 VEGETATION.

As previously noted, the south-eastern Cape is phytogeographically complex, as it is at the point of convergence of the five major phytochoria (Cowling, 1983). Close examination of the vegetation composition shows that

it is transitional between a typical Cape flora and a subtropical flora of southern Africa, with patches of well developed Afromontane forests. A further characteristic of this region is that it is situated where many taxa of diverse phytochorological affinities reach the limits of their distribution. Therefore, the proportion of endemics is low relative to rich endem centres in southern Africa (Cowling, 1983). The result of this chorological complexity is a mosaic of communities each with different chorological affinities or communities with a chorologically mixed flora.

It is against this rather complex background that the vegetation of the Winterberg plateau is described, using Acocks' (1953) classification. The vegetation varies along an altitudinal gradient, from False Thornveld on the dry lower slopes, to Afromontane forest, Macchia, and grasslands on the upper plateau.

i. False Thornveld of the Eastern Cape.

The lower southern slopes of the Elandsberg are dominated by sourveld grasses, particularly *Themeda triandra, Sporobolus fibriatus* and *Digitaria* spp. This grassveld is interspersed by *Acacia karroo, Aloe ferox* and *A. arborescens*. The grasslands are found along a narrow zone on the leeward slopes and are being encroached by "thorn scrub" due to overgrazing and mismanagement (Acocks, 1953). The resulting False Karroid Brokenveld is a poor substitute for the dense grassveld and has limited grazing potential. The recent encroachment by *Acacia karroo* is discussed by Bews (1917), Bayer (1933), Story (1952) and Acocks (1953). The invasion of the grassveld by "thorn scrub" has occurred over a wide area along the western margins of the grassveld areas, causing much alarm and destruction to the valuable grazing areas (Greathead, 1894; Hobson, 1896; Murray and Glover, 1935; Story, 1952).

ii. Afromontane Forest.

These forests are confined to the wet southern slopes and kloofs of the Winterberg and Amatole Ranges. Acocks (1953) describes these areas as transitional coastal forest. The canopy of the forests reach heights of 12-15 metres (Martin and Noel, 1960). Ferns, saprophytic fungi and lichens are common in the moist understorey. The understorey comprises a number of shrubs and creepers, including *Alchemilla* spp, *Streptocarpus rexii, Amaranthus thunbergii, Trichocladus ellipticus* and *Polygala myrtifolia.* The dominant tree species of the canopy include *Podocarpus latifolius, Olea capensis* and *Rhus legatii* (Story, 1952).

iii. Macchia.

This vegetation, usually known as fynbos, is described by Acocks (1953) as False Macchia and is found on the summits of the Winterberg, Elandsberg and Amatoles. The wetter southern aspects have a transitional forest climax, whereas the northern leeward slopes grade gradually into Dohne Sourveld. Acocks (1953) suggests that there are indications that in its natural condition, this Macchia would have been transitional from Dohne Sourveld and true Macchia. According to Story (1952) this fynbos is dominated by *Cliffortia paucistaminea,* and *Erica brownleeae.* Other constituents of the fynbos are *Protea lacticolor,* which is indicative of moist environments, *Bobartia gracilis, Rubus rigidus, Stoebe vulgaris, Passerina* spp and *Metalasia muricata.* The fynbos seems to grow best on the south-facing mountain slopes, where soils are acidic and infertile (Martin and Noel, 1960).

iv. Dohne Sourveld.

The leeward undulating Elandsberg Plateau grades from Macchia to sourveld grasslands, which are dominated by *Themeda triandra, Heteropogon contortus, Eragrostis capensis* and *Bromus firmior.* Wind exposure and snow in winter restricts trees and bushes to the lower altitudes, but the following forbs are found: *Athrixia phylicoides,*

Anthospermum spp, *Berkheya decurrens*, *Cineraria* spp, *Helichrysum* spp and *Geranium ornithopodium*. Selective grazing on these mountains has caused *Helichrysum argyrophyllum* and false fynbos elements to invade the grasslands (Story, 1952). This vegetation surrounds the immediate vlei areas and may be expected to be represented in the recent past of the fossil record.

v. Vlei Environment.

The vegetation of the vlei is typically hydrophytic, with sedges being dominant. Common taxa include *Scirpus* spp, *Tetraria* spp, *Pentaschistis* spp, *Kniphofia* spp and *Mentha aquatica*. A thick mat of decaying *Scirpus* and *Pentaschistis* forms the organic surface layer of the vlei. On the drier margins, *Helichrysum* spp and *Pteridium aquilinum* occur. The underlying soils are fertile and deep and therefore, popular for cultivation purposes. Only undisturbed vleis are selected for these palaeoecological studies.

vi. Conclusion.

The present vegetation of the Elandsberg is composed of a mosaic of different vegetation types. The vegetation grades from thornveld on the drier coastal plains to forest on the moister hillslopes. Above the forest where it is cooler, Macchia vegetation occurs. On the wind-blown leeward plateau, sourveld grasslands dominate. Story (1952) speculates that if the Elandsberg escarpment were higher, the climate would be drier and cooler, and a xerophytic Afroalpine vegetation would occur. Xerophytic vegetation would therefore, have expanded on this plateau during drier climates, which may be represented in the fossil record.

3.4 SNEEUBERG RANGE.

3.4.1 INTRODUCTION.

An incised vlei on the slopes of the Sneeuberg Range was chosen as a suitable study area in the north-eastern Karoo. This site differs from others in this study in that organic samples are taken from a three metre donga or gully (Plate 3.2) which has eroded an area that was at some stage a waterlogged vlei. The Sneeuberg Range is located between the Nuweveldberg and Winterberg sites.

3.4.2 TOPOGRAPHY AND LOCATION.

The Sneeuberg Range forms part of the Great Escarpment, joining the Central Karoo Mountains to the Eastern Cape and Drakensberg Ranges. These mountains are intruded by dolerite and comprise a number of peaks, the highest of which is Compassberg, reaching a height of 2 502m. Other prominent mesas include the Winterhoekberge (2 052m), Meiringsberg (2 083m) and Tafelberg (1 641m). Again, these remnant mesas form part of the original "African" surface. South of the Sneeuberg are the Camdeboo Plains (±900m) which rise sharply to the Middle Plateau at Nieu-Bethesda (±1 500m). The altitude increases still further to the summits of the above-mentioned peaks. The northern leeward slopes are gentle and merge into an undulating landscape. The interior plateau (1 300 - 1 500m) is dissected by a number of rivers which flow north into the Orange River.

The study area is at the headwaters of the Klein Seekoei River, on the slopes of the Compassberg and at an altitude of 2 000m (Figure 3.8). The Seekoei River is a tributary which drains the southern rim of the Central Orange River basin. The dolerite dykes form impervious barriers to the shallow groundwater moving through the gently dipping shales and force it to the surface at points where surface drainage converges on gaps in the dolerite ridges (Cole, 1961). These springs are highly dependable and are affected only

Plate 3.2 The three metre gully on the slopes of Compassberg Peak, Sneeuberg Range.

only by the most prolonged drought (Sampson, 1984b). The more fertile soils derived from the dolerite have caused specific plants to concentrate in these areas, imposing an additional ecological control on the vegetation distribution (Sampson, 1984a). Compassberg Vlei ($31^{0}45'37"S$; $24^{0}32'22"E$) is located on Compassberg Farm, which belongs to Mr K. McCabe. This farm has recently been proclaimed a Conservation Area, which will ensure that the natural vegetation is conserved and protected.

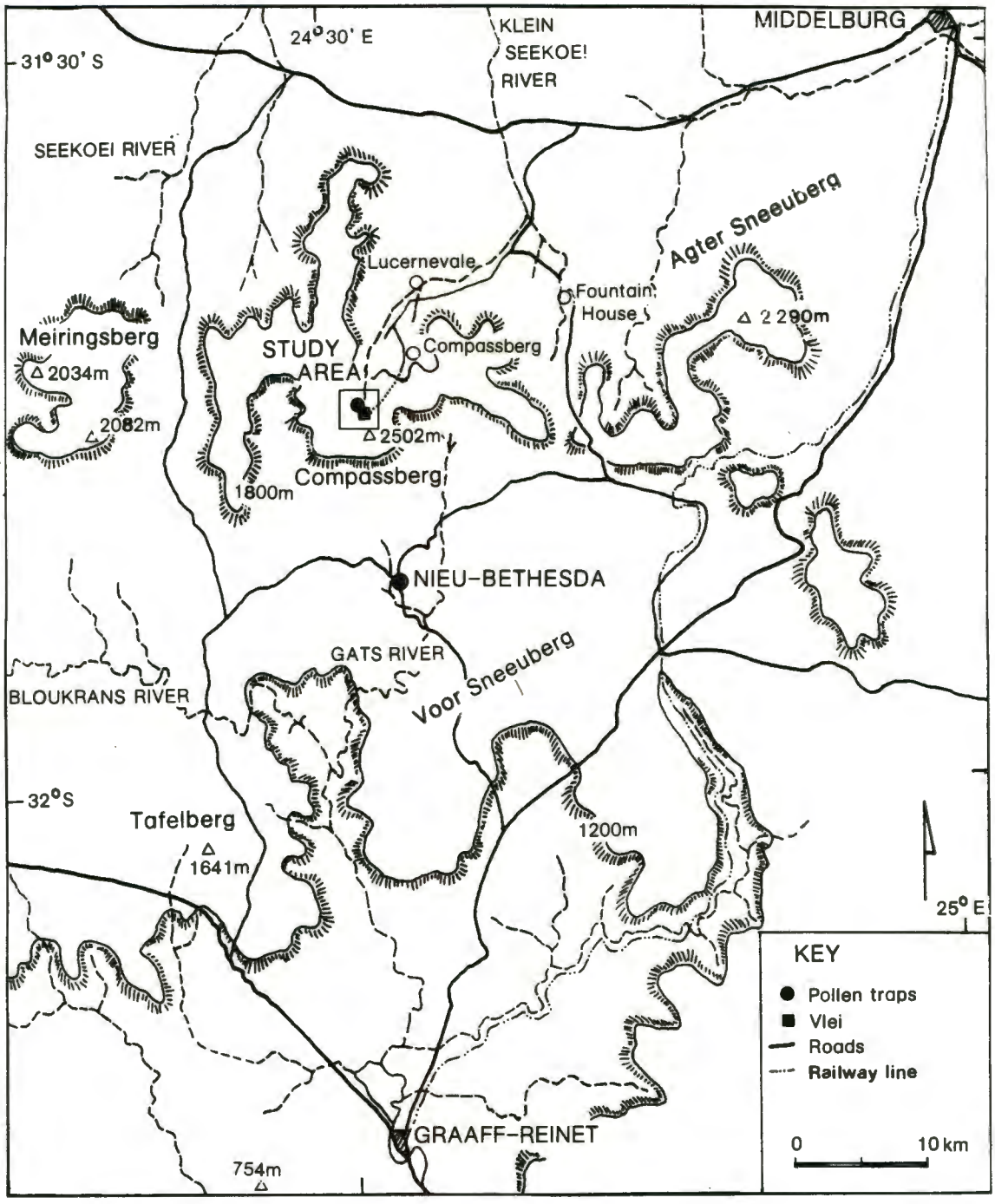

Figure 3.8 The Sneeuberg Range and the location of the gully on the slopes of the Compassberg.

3.4.3 GEOLOGY AND SOILS.

i. Local Geology.

The geology of the Sneeuberg area is similar to that of the Nuweveldberg Range (Section 3.2.2). The Sneeuberg is situated on the eastern side of the Great Karoo Basin, which is composed of sedimentary rocks of the Karoo Supergroup. Beaufort Shales underlie the large flat basins and plains of the interior plateau. The dolerites form rubble-strewn hill-swarms and sinuous ridges, which divide the Karoo Flats (Cole, 1961). Bedrock is covered by thin soils in most areas, except in stream and river valleys.

ii. Superficial Deposits and Vleis.

The gradient of the leeward slopes of the Compassberg is gentle and forms the Upper Karoo plains, at an altitude of between 1 300 and 1 500m. The northern flank of the Sneeuberg is dissected by ridges and hills of intrusive doleritic dykes and sills. Many north-flowing tributaries of the Seekoei River dissect this landscape as they flow towards the Orange River. At the headwaters of the Klein Seekoei River, a vlei has been incised by a gully, thereby exposing three metres of alluvial sediments. This stream seems to have been obstructed by doleritic intrusions, which caused the slow buildup of sediment to occur in the vlei. Subsequent energy fluctuations have caused a renewed geomorphological cycle of erosion to occur, thus exposing the palaeosols. Within the sequence of alluvial sediments, an organic deposit is evident between 30 and 90cm below the surface. The basal material, containing 10-15% of finely divided organic detritus, rests on a less organic sandy alluvium and grades upwards into a fibrous, carbon-rich horizon. Numerous incised valley fills occur on the Sneeuberg plateau, but most have been disturbed for cultivation purposes. At Blydefontein, some 75km to the north-east of the Compassberg, a detailed geomorphological survey of similar palaeosols and sections has revealed a series of such palaeosols, which are formed in "younger"

fills, which are of later Holocene age (Bousman *et al.*, 1988).

iii. Soils.

The central Karoo is described as an area of rocky soils of sandy-loam, shale and sandstone, interrupted by dolerite hills. Silt flats occur along some of the rivers as a result of sheet and river erosion (Werger, 1978). In this area the bedrock of Beaufort Shales are covered by thin soils (Sampson, 1984b), which Ellis and Lambrechts (1986) classify as duplex soils.

3.4.4 CLIMATE.

The Sneeuberg is within the eastern region of the Warm Temperate Zone. The climate is similar to that occurring at the Nuweveldberg, but receives a slightly higher annual rainfall of 346mm (Schulze, 1979). On the Compassberg the annual rainfall increases to almost double this value due to increased altitudes and drops to below 346mm per annum on the northern plateau (Venter, Mocke and de Jager, 1986). The rainfall is largely due to convectional showers and thunderstorms, peaking in February or March. Snowfalls are frequent during winter, but limited to the upper mountainous areas. Meltwaters are important as most of the moisture is able to infiltrate the soil (Schulze, 1979). Although the average annual rainfall is not very high on the plateau, the area is nevertheless well watered. This is due to the good water retention near the surface caused by the underlying shales and the intrusive dykes and sills (Sampson, 1984b). Temperatures are subject to large diurnal and seasonal variation. The average daily maximum in summer lies between 30^0 and 33^oC, whilst extremes of -11^oC have been recorded in winter (Schulze, 1979).

3.4.5 VEGETATION.

The vegetation of the Sneeuberg is characterised by karroid scrub on the plains and sourveld grasslands on the mountainous uplands. The karoo shrubland (White, 1983) is dominated by dwarf shrubs, most of which belong to the family, Asteraceae. This vegetation occupies the Central Upper Karoo and the lower slopes of the Karoo Mountains. Bushes and trees are absent, but *Acacia karroo* is encroaching onto the Central plains. Large shrubs are few, being represented chiefly by *Rhigozum trichotomum* and *Rhus undulata*. Grasses are more abundant than in the Western and Central Karoo and increase towards the east. Werger (1978) describes the vegetation as a treeless scrub, with excellent nutritional values and consequently a very high carrying capacity which belies its bleak appearance. From a hunter-gatherer's viewpoint, this is a rich habitat as at least six edible tubers are found in abundance in the region.

According to Acocks' (1953) classification, this area may be divided into three veld types: Karroid Merxmuellera Mountainveld on the mountainous areas; Merxmuellera Mountainveld replaced by karoo at the foothills of the mountains; and False Upper Karoo on the Northern Upper Plateau.

i. Mountainous areas.

On the Sneeuberg Range, Karroid Merxmuellera Mountainveld is restricted to the mountainous regions and higher altitudes. In areas where bare rock, particularly dolerite is exposed, a sparse, semi-succulent vegetation is found. The principal succulents are *Ruschia* spp, *Adromischus* spp and *Crassula* spp. Karroid Merxmuellera Mountainveld replaced by karoo occurs around most of the Merxmuellera Mountainveld areas. It tends to develop in the surrounding valleys, where grazing is heaviest and most continuous. At the lower margins, it is indistinguishable from False Upper Karoo, except for occasional tufts of *Merxmuellera disticha*. A feature of this veld type is soil erosion, still very

actively removing the deep black vlei soil of the mountain valleys (Acocks, 1953). This observation by Acocks is a good description of the Sneeuberg plateau north-west of the Compassberg where gullies, such as that of the study area, expose the vlei sediments.

ii. Northern Upper Plateau.

False Upper Karoo (veld type 36) occupies the plateau north of the Compassberg. The characteristic shrub of the hills is *Rhus undulata*. On the plateau, the flora is more diverse than the grasslands, with *Lycium* spp, *Tribulus terrestris* and *Ifloga paronychades* dominating (Sampson, 1985a). The occasional patches of alluvial sand amongst the hills carry an *Aristida diffusa - Eriocephalus ericoides* veld. Common dwarf shrubs include *Pentzia* spp, *Pteronia* spp, *Felicia muricata, Chrysocoma tenuifolia* and *Salsola* spp (Werger, 1978). *Chrysocoma tenuifolia* is thought to be one of the most prominent and aggressive invaders, especially in the overgrazed grassveld (Roux, 1984). Its presence in the eastern Karoo is thought to be indicative of veld deterioration.

3.5 THE NUWEVELDBERG RANGE.

3.5.1 INTRODUCTION.

The Nuweveldberg Range is centrally located within the Karoo Biome and forms part of the chain of escarpment mountains. Fortunately, vleis (eg. Bokkraal) which contain polleniferous organic deposits are found on the upland plateau of this range, forming an ideal site in an area where the vegetation assemblages are clearly differentiated. Due to the aridity of this area, palaeoenvironmental fossil evidence is poorly preserved and little is known about former environmental conditions. Botanically, this area has been relatively poorly studied, but is gaining interest,

thanks to the initiation of the Karoo Biome Project (Cowling, 1986).

Bokkraal Vlei was selected as the most suitable vlei on the Nuweveldberg for palynological investigations (Plate 3.3). The vlei is located in the Karoo National Park, which is advantageous as floristic data are available, the pollen traps are secure and the vegetation will have minimal disturbance from farming activities.

Plate 3.3 Bokkraal Vlei on the Nuweveldberg Range. Merxmuellera Mountainveld covers the upper plateau.

3.5.2 LOCATION AND TOPOGRAPHY.

The Nuweveld Range forms the Central Karoo link of the Great Escarpment. This range forms the division between the Upper Karoo to the north of the Escarpment and the Great Karoo to the south. From the Upper Plateau the vast Karoo Plains stretch endlessly to the Swartberg Mountains, which are part of the Cape Folded Belt. The Nuweveldberg comprises a number of flat topped mesas, reaching heights of 1 956m at

Tafelberg. The rock formations consist mainly of Beaufort sandstones and shales, in which various dolerite intrusions occur. The well developed joint systems in the dolerite sills are displayed in the columnar structures on the Nuweveld escarpment.

The Nuweveldberg range, trending in a north-east to south-west direction, rises sharply from the Great Karoo plains which are at 846m, to altitudes of approximately 1 750m. The northern leeward plateau grades gently down to 1 000m. Bokkraal Vlei is situated on this leeward slope, near the scarp edge of the Nuweveldberg. The vlei, which is 600m in length and 200m wide, is located behind a poplar plantation in the vicinity of an old ruin on Bokkraal Farm ($32^{o}15'55"S$; $22^{o}29'40"E$); the exact position is shown in Figure 3.9. The valley in which the vlei is situated is constricted by a dolerite dyke which traps the water and provides ideal conditions for the development of stratified organic sediments. The availability of fertile soils and water is limited and, therefore, all areas suitable for cultivation have been utilised. Unfortunately, the larger, more extensive vleis on the Sak River have been channelised and drained for cultivation purposes and were not suitable for palynological investigations.

3.5.3 GEOLOGY AND SOILS.

i. Local Geology.

The Nuweveldberg is situated in the Great Karoo Basin. It is composed of sedimentary rocks of the Karoo Sequence, intruded by dolerite dykes which form the resistant mountain summits. In this region, the sequence comprises four geological formations viz: Ecca Group, Beaufort Group, dolerite and alluvium (Theron, 1983).

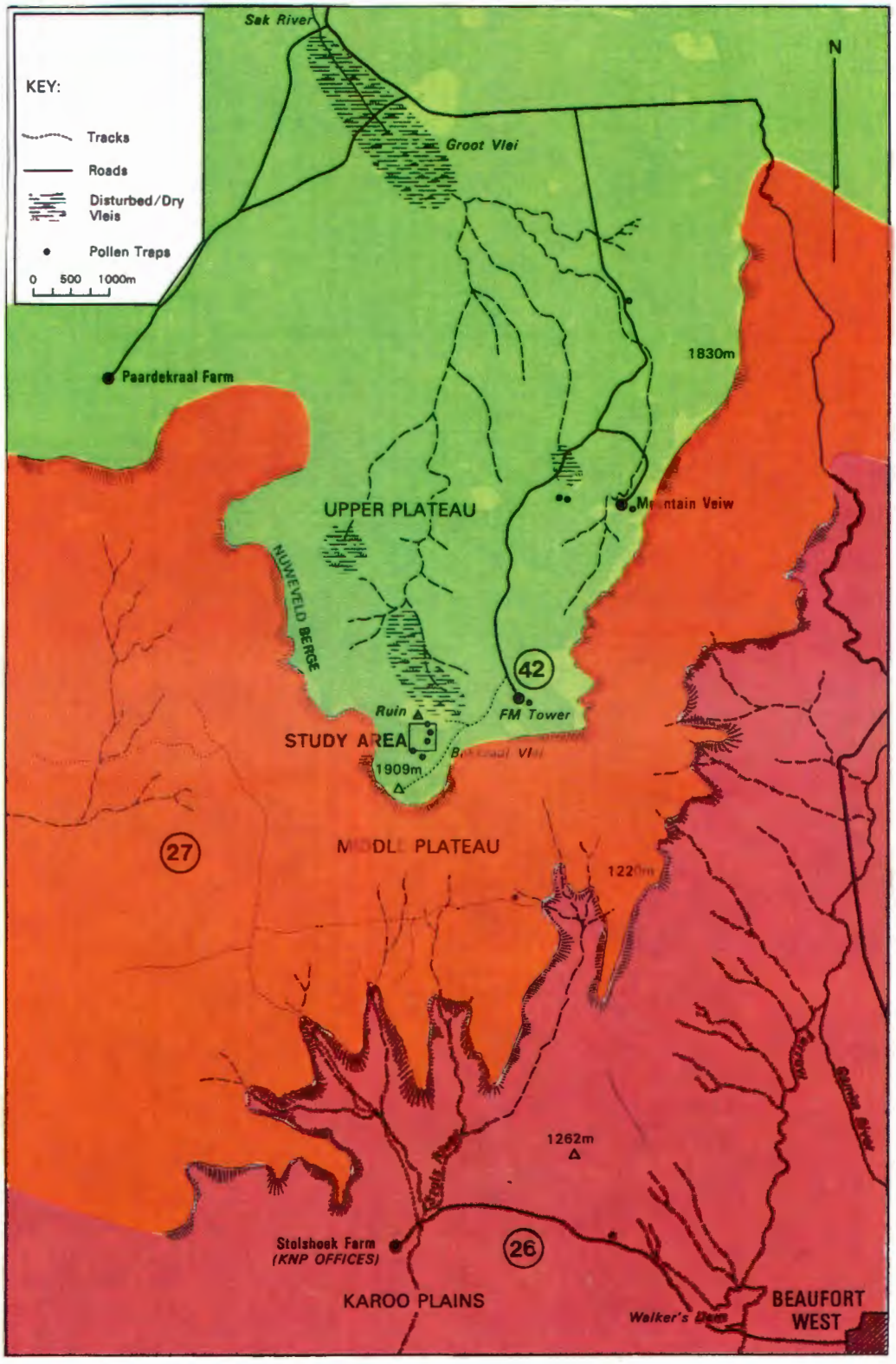

Figure 3.9 The Nuweveldberg Range, showing the location of Bokkraal Vlei and the dominant veld types as indicated by : 42, Merxmuellera Mountainveld; 27, Upper Karoo; 26, Karroid Brokenveld.

ii. Superficial deposits and vleis.

The leeward side of the Nuweveldberg upper plateau is characterised by a gently sloping, undulating landscape, interspersed with isolated mesas, buttes and koppies. Resistant dolerite dykes and sills are exposed in the weathered valleys and middle plateau. Well-developed joint systems in the dolerite have resulted in tors and large boulders being abundant on the upland plateau, whereas desert pavement, deflation pans and other features resulting from wind erosion are marked on the Karoo plains (King, 1951).

The north-flowing tributaries of the Sak River have had little influence on the undulating slopes, whereas the perennial south-flowing tributaries of the Gamka River have eroded deep steep-sided valleys on the eastern slopes of the Nuweveldberg (Figure 3.9). The streams have little deposition, but vleis have developed where dykes constrict their flow, causing deposition and the accumulation of organic sediments, as found in Bokkraal Vlei. Several large, deep vleis, for example Grootvlei, were sampled during the pilot study. Although these sediment deposits extend to depths of up to 2.5m and contained highly organic sediments, they have been disturbed for cultivation purposes, thus rendering them useless for palynological analyses. Black amorphous organic sediments, of a lower organic content than those found in the Winterberg, have accumulated on the coarse weathered sand of the underlying bedrock. It is not surprising that in the central semi-arid Karoo, the organic content of the vlei sediments is lower than that of the more mesic eastern mountains. Generally, the low vegetation cover and the xeric conditions are not conducive to the slow degradation process required for the formation of peat.

The sediments of Bokkraal Vlei consist of fibrous black organic matter from 0 to 40cm, which overlies the compact, black, amorphous organic sediments that extends to depths of

125cm. The sediments in the vlei are waterlogged for most of the year and represent a suitable environment for organic sediment accumulation and the preservation of fossils. Sediment analyses were conducted to assess changes in sediment characteristics, as clastic sediments accumulating in linear, flat-bottomed vleis are good climatic indicators in themselves (Meadows, 1988a; Dewey, 1988).

iii. Soils.

The soil types follow the broad geological classifications, but are influenced by wind erosion and the prevalence of doleritic intrusions. The soils of the Karoo plains are thin and poorly developed in comparison to the deeper duplex soils found on the Nuweveldberg plateau. The reddish coloured duplex soils of this area have developed in parent materials rich in dolerite weathering products. The distinguishing characteristics of these soils are the massive to platey structured loamy A horizon, overlying a structured B horizon (Ellis and Lambrechts, 1986). These alluvial soils are associated with low-lying flat pediment slopes, smaller pans and extensive pans. The soils are shallow (less than 500mm to the hard rock or calcretes) with nutrient-rich A horizons ranging in texture from sand to loamy-sand to sandy-clay (Ellis and Lambrechts, 1986).

3.5.4 CLIMATE.

The Nuweveldberg area falls within the Warm Temperate Zone in the semi-arid interior of the Cape Province (Schulze, 1979). This climatic zone receives an average of less than 250mm of rain per year, but in the upper reaches of the mountains it may increase to 750mm. Rain occurs throughout the year, but peaks during February and March. Snowfalls are frequent during winter, but limited to the mountainous areas. The climate is influenced by the subtropical high pressure belt and its characteristic dry, upper air. Convectional thunderstorms in summer bring most of the moisture to this area. Runoff and evaporation rates are

high, thus removing a large proportion of the much-needed moisture. Violent thunderstorms are a feature of this area, as are the large diurnal and seasonal temperature fluctuations (Werger, 1978). In summer, the days are excessively hot, with temperatures exceeding 40°C, whereas on winter nights temperatures may drop to below -10°C (Schulze, 1979).

It is a windy region, with south-easterlies dominating in summer and north-westerlies in winter; wind-pruned vegetation is apparent on the mountaintop and features resulting from wind erosion for example, deflation pans and desert pavement, are found on the plains. The hot "Berg" winds off the high plateau have a desiccating effect on the vegetation of the Great Karoo. There are local variations in climate from the Karoo plains to the Upper Plateau and the northern slopes are substantially drier than the southern slopes. Generally, the areas at greater altitudes have an associated increase in moisture availability and receive additional moisture in winter in the form of snow. This is trapped in the vegetation and is able to infiltrate the soil and be utilised by plants.

3.5.5 VEGETATION.

The vegetation of the Central Karoo is dominated by a mixed grass/shrub component, representing the transition from the western shrubveld to the eastern grasslands. The vegetation in the Nuweveldberg area is heterogenous and the composition is influenced by topographical and geological differences, which in turn cause changes in the microclimate and soil structure. Acocks (1953) recognises three major veld types in the Nuweveldberg as one progresses up what amounts to a moisture gradient, from the Karoo plains to the upper plateau on the top of the mountain.

i. Karoo Plains.

Karroid Brokenveld (veld type 26) occurs on the Karoo plains and gentle slopes on the leeward side of the Nuweveldberg Range and is typical of the vegetation of the Great Karoo. In this veld type, succulents are relatively sparse and grass species are numerous, but sparsely distributed. Dwarf shrubs are found in rocky areas and thornveld occurs along rivers where soils are deeper and moisture more freely available.

The area is dominated by "karoo bushes", which consist of a variety of dwarf shrubs characteristic of the denuded stony plains of the Karoo and adapted to xeric conditions. Small hardy shrubs, such as *Pentzia incana, Lycium oxycarpum, Rhigozum obovatum, Psilocaulon absimile, Eriocephalus spinescens* and *Galenia fruticosa* dominate this vegetation (Acocks, 1953; Karoo National Park Brochure, 1986). Although perennial grasses are not common, *Stipagrostis obtusa, S. ciliata* and *Enneapogon scaber* are conspicuous on the moister flats.

ii. Middle Plateau.

On the infertile middle plateau the Central Upper Karroid veld type occurs and is characterised by dwarf shrubs and bushes. The mountains have more grass than the plains, with the mountaintops being covered by Karroid Merxmuellera Mountainveld. These plateaux have a complex vegetation pattern, in which the plant composition alters according to the difference in topography and soils. Generally, the dolerite areas of the resistant mountainous parts have well established stands of grass, while on shales, plant communities do not seem to flourish. This veld type is to some degree invaded by elements of the Karroid Brokenveld. The grasses are predominantly of the "white type", represented by *Eragrostis lehmanniana, E. obtusa, E. bicolor, Stipagrostis obtusa* and *Aristida congesta*. The dominant shrubs include *Rhus lucida, Limeum aethiopicum, Chrysocoma tenuifolia, Elytropappus rhinocerotis, Grewia*

robusta and *Eriocephalus* spp (Acocks, 1953; Karoo National Park Brochure, 1986).

iii. Upper Plateau.

On the upper plateau of the Nuweveldberg where precipitation is higher, Karroid Merxmuellera Mountainveld (veld type 42) dominates. The dominant grasses are *Merxmuellera stricta, M. disticha* and *Themeda triandra* (Acocks, 1953). Trees are almost totally absent, apart from a few *Cliffortia arborea, Kiggelaria africana* along dried-up stream beds and the recent Poplar stand near Bokkraal Vlei. In the disturbed areas, the grasslands are invaded by Dwarf Karoo Shrublands and Renosterveld (White, 1983). This vegetation is Macchia-like, with many resinous, aromatic dwarf shrubs, including *Passerina montana, Elytropappus rhinocerotis, Stoebe vulgaris, Euryops* spp and a variety of *Pelargonium* species (Karoo National Park Brochure, 1986).

iv. Vlei Environment.

The entire surface of Bokkraal Vlei is covered by hydrophytic vegetation, including a variety of Cyperaceae and Juncaceae; aquatic herbs, particularly *Mentha aquatica, Kniphofia rooperi,, Trifolium burchellianum* and a few Restionaceae species. The vlei is surrounded by Karroid Merxmuellera Mountainveld and a plantation of *Populus alba* forms the north-western boundary of the vlei.

v. Conclusion.

The Nuweveldberg area is covered by a mixed grass-shrub vegetation. Dwarf shrubs are typical of this region and can be succulent or narrow-leaved. Dwarf scrub formations range from fairly dense on the moister sites, to open formations in the arid and overgrazed areas. The narrow-leaved dwarf scrub formations cover the wide plains between the koppies and mountain ridges, while on the rocky slopes, larger shrubs and grass tufts are common and sometimes develop into shrublands. The grass component in these areas

varies greatly depending on the soil type and degree of overgrazing. The doleritic soils and increased moisture of the upper areas therefore enable the grasses to dominate over the dwarf scrub.

The climatic gradient on the dry northern slopes of the mountains is more marked than on the windward slopes, and environmental variations are apparent over short distances in the rainshadow areas. The mountain ridges and upper doleritic plateau are covered by *Merxmuellera* grasslands, but on the lower shale and sandstone plains of the interior plateau, there is a distinct transition to Karroid Brokenveld (Plate 3.4). The expansion of this dry karroid vegetation of the plains and associated invasion of the *Merxmuellera* grasslands during drier climatic phases should be reflected in the fossil record.

Plate 3.4 A clear vegetation boundary between Karroid Brokenveld and Merxmuellera Mountainveld on the northern slopes of the Nuweveldberg.

The vegetation of the Nuweveldberg is, therefore, comprised of three major types which correspond with the geomorphological zones: Karroid Brokenveld on the Karoo plains, Central Upper Karoo on the middle plateau and Merxmuellera Mountainveld on the upper plateau. It is the movement of these vegetation assemblages in response to climatic fluctuations that are of interest in this palaeoecological study.

3.6 THE CEDERBERG RANGE.

3.6.1 INTRODUCTION.

The Cederberg Mountains are situated within the Fynbos Biome (Kruger, 1978; Taylor, 1980; Deacon *et al.*, 1983) and are part of the Cape Fold Mountain System. Immediately east of these mountains, an abrupt change in geology and vegetation indicates the boundary or transition between the Karoo and Fynbos Biomes (Werger, 1978). The Grootberge and Roggeveldberge are within the Karoo-Namib Domain, and form the western extent of the Great Escarpment (Figure 3.10). Unfortunately, no vleis or deep organic deposits have so far been identified in these regions. The Roggeveldberge are situated in the winter rainfall region of the Tanqua Karoo. The annual rainfall in this area is between 100 and 200mm (Venter *et al.*, 1986) and the vegetation is extremely sparse. This area has been severely trampled and eroded, resulting in a substrate which consists largely of gravelly sand or brackish alluvial silt (Werger, 1978). Conditions are therefore, not suitable for the accumulation of organic sediments or for vlei development.

The Karoo and Fynbos floras have many common genera, but vegetation boundaries between Karoo and Fynbos are distinct and usually associated with the shale-quartzite interface. There is, however, a strong karroid component in the renosterveld communities on the shaley coastal forelands of

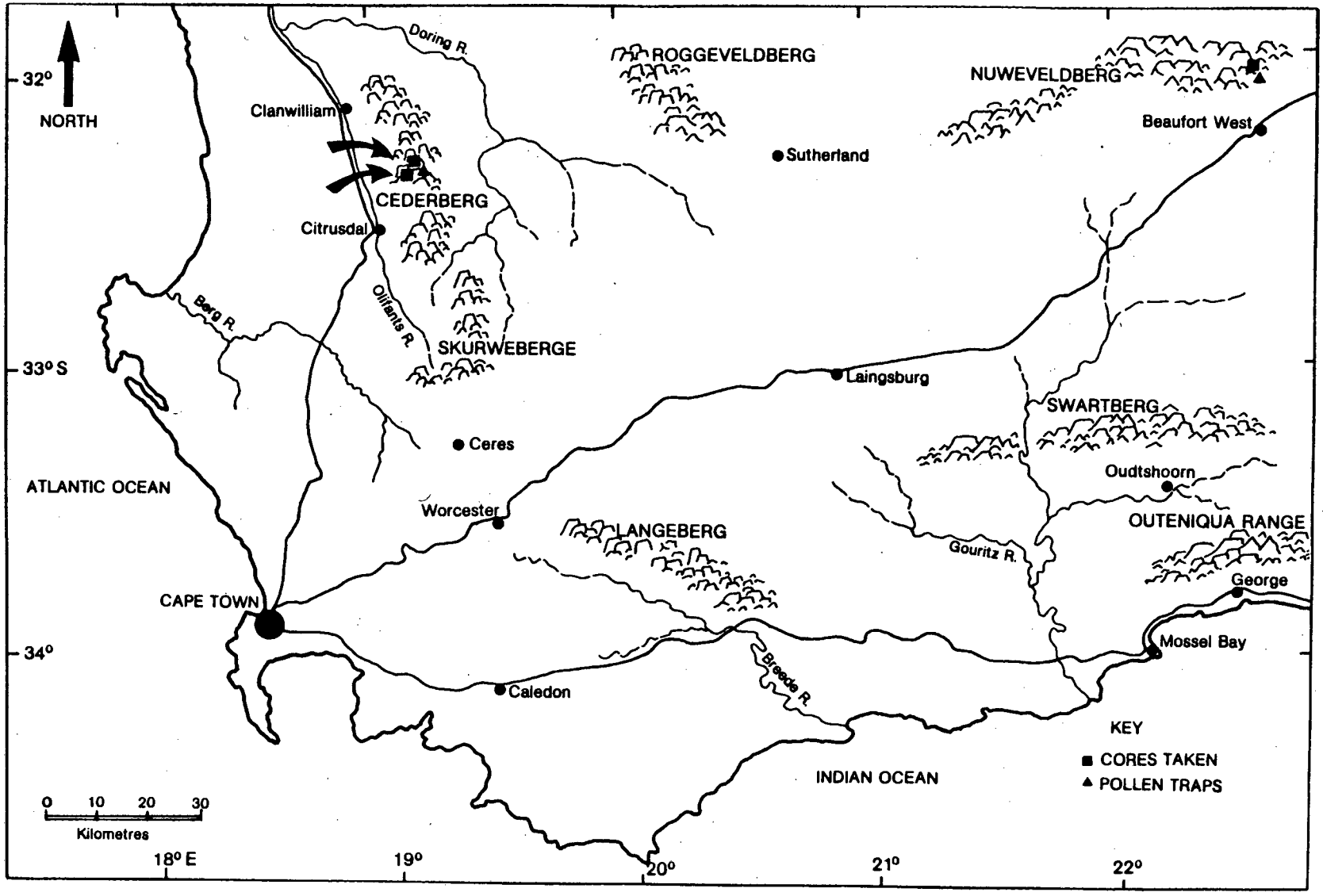

Figure 3.10 The location of the Cederberg Mountains in the south-western Cape.

the Fynbos Biome (Werger, 1978; Cowling, 1986). In the south-west the Karoo region is clearly separated from the Capensis region. This boundary was first documented by Bolus (1875) and consists of several folded mountain ridges which lie parallel to the coastline in the south-western Cape. Depending on the height above the surrounding plains, slope direction and distance from the coast, the mountain ridges receive varying amounts of precipitation, with the southern slopes receiving more rain than the northern slopes. These ridges are separated by narrow to very wide arid valleys and depressions. The Karoo-Namib flora occupies the arid parts, whereas the wetter slopes are vegetated by renosterbosveld and fynbos communities (Compton, 1929).

The open succulent karoo is within the Western Cape Domain of the Karoo-Namib Region (Werger, 1978). The Tanqua Karoo is situated east of the Cederberg and Koue Bokkeveld Mountains and west of the even rainfall region of the arid Karoo (Cowling, 1986). This area receives between 100 and 200mm of rain annually, is severely eroded and sparsely vegetated by an open dwarf succulent shrubland in which Aizoaceae are prominent. The Cederberg Range, on the other hand, is within the Cape Floral Kingdom which is concentrated in the region known today as Capensis (Taylor, 1980). This region is bounded to the west and south by the coast and to the north and east by the Karoo-Namib Region (Werger, 1978). Vleis in the Cederberg Range have been chosen to represent the study area on the western extreme of the trans-Karoo study.

3.6.2 LOCATION AND TOPOGRAPHY.

The Cederberg mountains form the north-westerly extreme of the Cape Folded Mountains, running parallel to the west coast as far north as Clanwilliam. This range, which has an average altitude of between 1 200 to 1 500m, has a number of sandstone summits, the most pronounced being Sneeuberg

(2 026m), Tafelberg (1 969m), Jurie se Berg (1 930m) and Krakadouberg (1 744m).

The Cederberg trend in a north-west to south-south-east direction and are dissected by a number of strongly flowing rivers. North-flowing rivers drain the western slopes and join the Olifants River, which flows along the foothills of the range. South-flowing rivers drain the eastern slopes, converging to form the Riet River which provides water for the plains of the arid Tanqua Karoo. The western slopes of the Cederberg rise sharply from the coastal plains which are between 500 and 800m, to heights of approximately 1 300m on the Cederberg Plateau. East of the Cederberg is a lower range of mountains, the Hottentotsberge and Swartruggens, which give way to the plains of the Ceres Karoo.

The vleis which were sampled are Driehoek Vlei (Plate 3.5) and Sneeuberg Vlei (Plate 3.6). They are situated on the Cederberg Plateau, at differing altitudes, as shown in Figure 3.11. Driehoek Vlei ($19^{0}08'30"E$; $32^{o}26'15"S$), at an altitude of 900m, is situated at the headwaters of the Driehoek River and on the "Middle Plateau" of the Cederberg Range. This vlei is large: 850m in width and extending for approximately 8.5km. The coring site is located in a moist area 4.5km from the headwaters. Sneeuberg Vlei ($32^{o}26'48"S$; $19^{o}08'55"E$) is situated at an altitude of 1 440m on the Upper Sneeuberg Plateau. This vlei is smaller, being confined by outcrops of resistant sandstone. It is approximately 1 000m in length and 600m in width.

3.6.3 GEOLOGY AND SOILS.

i. Local Geology.

The Cederberg Mountains are situated at the north-eastern fringe of the Cape Supergroup (Visser, 1986), and are comprised of rocks from the Table Mountain Series. This series has folded into an anticline which forms the

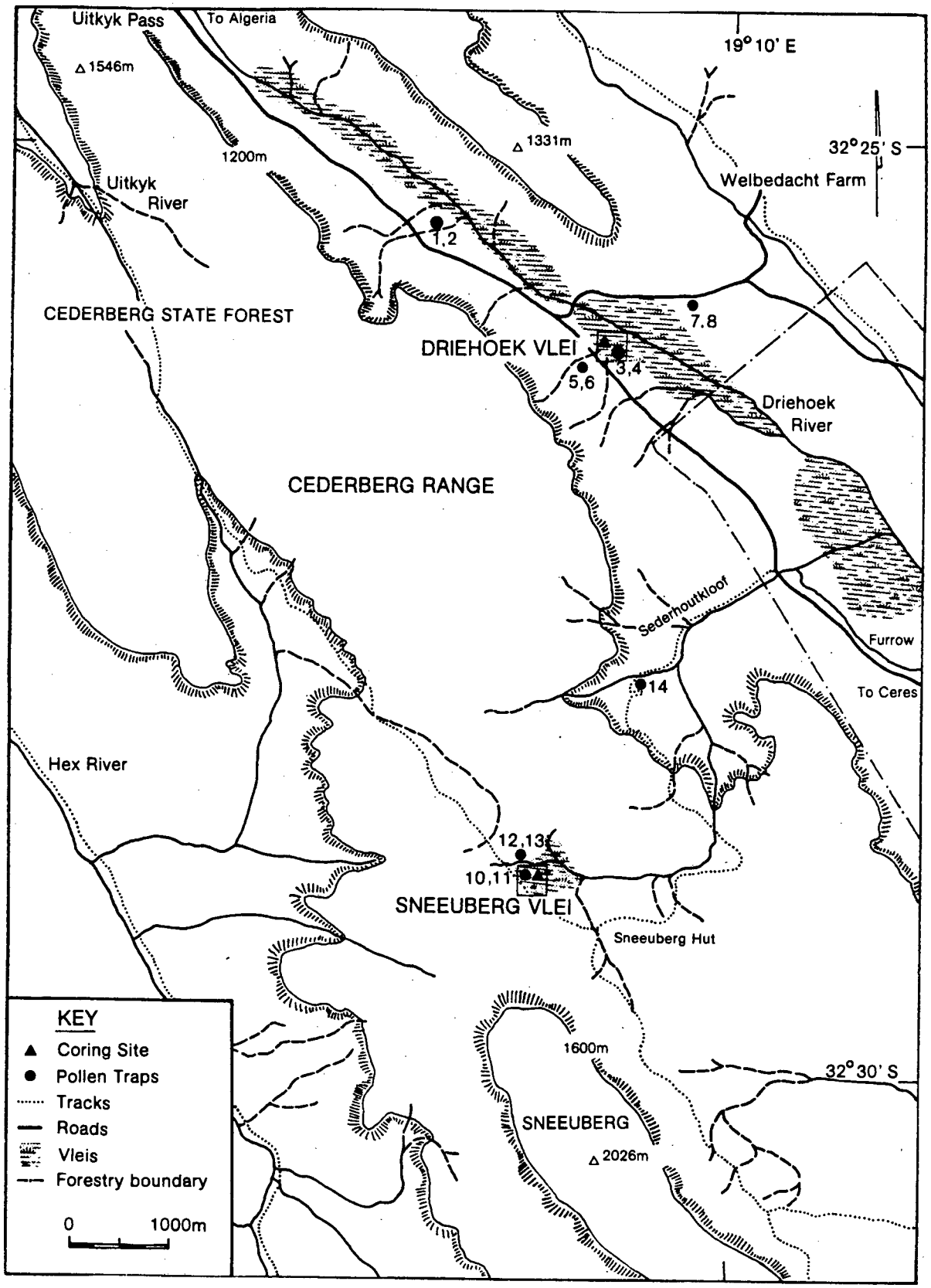

Figure 3.11 The Cederberg Range, showing the location of Driehoek and Sneeuberg Vleis. The coring sites and pollen traps are indicated.

Plate 3.5 Driehoek Vlei, Cederberg Range.

Plate 3.6 Sneeuberg Vlei on the upper plateau of the Cederberg Range.

Cederberg, with the sandstone dipping eastwards below the slates of the Koue Bokkeveld (du Toit, 1954). The major ranges in this area are constructed of Table Mountain Sandstone and the minor ones of smaller sandstone folds or of Witteberg quartzites of the Cape System (White, 1978) as shown in Figure 3.12.

The Table Mountain series rests on tilted Malmesbury shales of the late Precambrian. In this area, the foothills and lower slopes are commonly formed of Cape Granites. The Western Cape facies of the Table Mountain Group consist of a lower and an upper whitish-grey quartzitic sandstone unit within which dispersed vein-quartz pebbles occur. At the base of this facies, conglomerate, shale and reddish-purple sandstone occur (du Toit, 1954). The bulk of the group is formed by orthoquartzites of the Peninsula and Nardouw Formations. The Peninsula Formation is resistant to erosion and gives rise to nearly all the prominent relief features in the Cederberg rocks (Truswell, 1977).

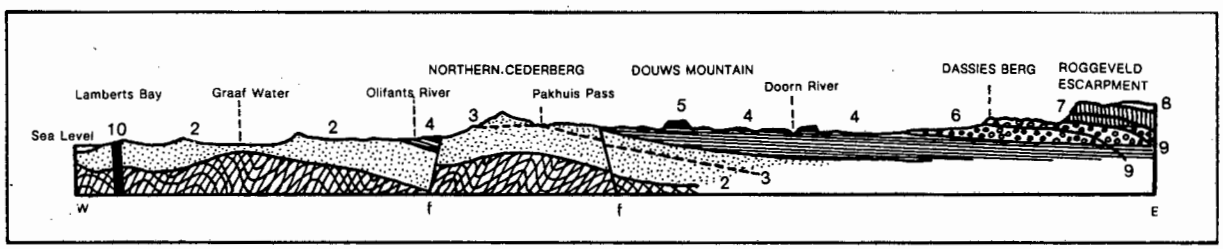

Figure 3.12 A geological transect through the south-western Cape Deposits. 1, Malmesbury Series; 2, Table Mountain Series, with (3) shale band and glacial horizon; 4, Bokkeveld Series; 5, Witteberg Series; 6, Dwyka Series; 7, Ecca Series; 8, Beaufort Series; 9, Karoo Dolerites; 10, Volcanic Neck; f, Fault (After du Toit, 1954).

The Ceres Karoo, to the east is underlain by Bokkeveld shales, with the Witteberg quartzites forming the remnant summits (Figure 3.12). Marine fossils in the lower portion of the Bokkeveld indicate a lower Devonian age for these rocks (Truswell, 1977).

The Bokkeveld Group follows conformably on the Table Mountain Sandstone. This series has an easterly dip and forms a narrow strip of low-lying ground passing to the east of the Cederberg, which is known as the Koue Bokkeveld. Beds of the Bokkeveld Group underlie long strips between the mountains. This phenomenon is the result of the Cape folding where the softer beds were preserved in the synclines (Visser, 1986). The alternation of softer and harder zones shows up conspicuously in the topography, the sandstones producing a regular series of low ridges or scarps and littering the shale slopes with their fragments. The Witteberg Group give rise to chains of quartzites with even crest-lines, while the slopes are thickly strewn with lumps of quartzites. This group lies conformably on the Bokkeveld Group and to the west is overlain by Dwyka tillite of the Karoo Sequence.

ii. Superficial deposits and vleis

The landscape is dominated by subparallel folded mountain ranges at altitudes of 1 000 to 1 500m and individual peaks exceeding 2 000m. On the table-top summits and upper plateau, the sandstone has weathered, forming a thin, grey porous sandy soil, dotted with quartz grains and pebbles. A conspicuous feature of this formation is the bare character of the ranges and the sandstone boulders which litter the scree slopes (du Toit, 1954). Differential weathering along joints in the granite and sandstone has left huge pillars and rock masses upstanding.

Numerous wetlands, bogs and vleis have been identified on the upland areas of the south-western Cape (H. Taylor, pers. commun., 1987). A large proportion of these depressions or sponges are on steep slopes, or within a granitic pediment and are therefore not suitable for the accumulation of organic sediments. On the table-top summits of the moister uplands, for example at Sneeuberg Vlei which is at an altitude of about 1 550m, deep humic soils have accumulated in the vlei due to the constriction of streamflow. In these

vleis, vegetation communities are structurally differentiated. The dense, low cushion tufts of *Restio curviramis* along the rocky edges of the seepage area become intermingled with a central community of *Cannomois* spp, which grows in dense erect tufts about 1m high.

In the Cederberg Mountain Fynbos there are numerous communities typical of permanently wet or moist sites. The range of habitats is enormous, being determined not only by their position in the soil moisture gradient, but also by the microclimate of the particular locality, fire regime and phytogeographical factors (Werger, 1978). On the Cederberg, organic sediments have accumulated over long periods in the wide synclinal folds or between resistant ridges of sandstone, resulting in vlei deposits of up to 5m. An example of this type of vlei is Driehoek Vlei, where stratified sandy organic sediments suitable for palynological investigations have accumulated.

Sneeuberg Vlei, which is situated on the upper plateau, some 500m higher than Driehoek Vlei, is part of a large seepage area which receives runoff from the surrounding summits. The streamflow is obstructed by resistant rocks which impede the flow of strongly flowing streams and provides conditions suitable for the accumulation of organic sediments.

iii. Soils.

Soil types follow the geological substrate. The soils of the Cederberg area are derived from the Table Mountain Sandstone Group and are generally coarse textured, shallow and nutrient-poor. Soils of the Tanqua Karoo are derived from Bokkeveld shales and are fine-grained and more fertile.

The quartzites of the Cederberg area give rise to soils that are acidic, nutrient-poor, coarse-grained, rocky and shallow. These soils tend to be better developed, that is, they are deeper, have a finer texture and are less rocky, on the south-facing aspects of gentler slopes. Clay-rich soils

are restricted to shales and granites, which are confined to lower mountain slopes. Campbell (1986b) examined the differences between fynbos and non-fynbos soils and concluded that nutrient conditions are an important controlling factor as to the type of vegetation occurring in certain areas. He postulates a gradient which runs from karroid and Renoster shrublands on the least nutrient-poor soils, to grasslands and grassy shrublands, eastern Fynbos and finally to Mountain Fynbos on the most nutrient-poor soils (Campbell, 1986b).

The substrate of the Tanqua Karoo consists of gravelly sand or brackish alluvial silt (Werger, 1978). The soils derived from the Witteberg Series are shallow, offering a poor substrate for the establishment of vegetation. The pasturage on the hills is extremely poor and the slopes are strewn with gneiss and quartzite pebbles. The lowland area comprises sandy alluvial plains, which may also be strewn with quartzite pebbles.

3.6.4 CLIMATE.

The Cederberg area is characterised by a Mediterranean-type climate, receiving more than 60% of its rainfall in winter, from May to September. Rainfall exceeds 250mm per year and is between 300 and 2 500mm on the summits (Schulze, 1979). The pronounced orographic features influence the rainfall markedly - maxima are reached on the summits, while a mere 150mm is received in the rain shadow area of the Tanqua and Ceres Karoo. On the higher mountains, summer aridity is alleviated by moisture-bearing clouds from the south-east. During winter, snow falls regularly on the higher mountains. Winter rains are associated with the penetration of cyclonic fronts, and the occasional cut-off low pressure cells in spring and autumn result in heavy falls (Heydorn and Tinley, 1980). Mean annual temperatures vary from 17.5^{o}C at inland stations to 13^{o}C at high altitudes (Schulze, 1979). Strong

desiccating "berg" winds are common during spring and autumn.

On the eastern slopes of the Cederberg and in the Tanqua Karoo, rainfall drops to below 200mm per annum. The boundary between the Western Cape Domain and the Karoo Domain of the Nama-Karoo is determined by a variety of factors, one of the most important being the season of rainfall. Hence, the Western Cape Domain receives virtually all its rain during winter (Werger, 1978). A feature of this intermediate region is the large diurnal and seasonal temperature range. The average daily maximum temperature is 24^{o}C in summer and 11^{o}C in winter (Schulze, 1979). The steep moisture and temperature gradients are important climatic factors with regard to the transition from Fynbos to Karoo.

3.6.5 VEGETATION.

Fynbos occurs within the Cape Floristic Region and is regarded as one of the six floral kingdoms of the world (Good, 1974). Despite the uniqueness and scientific interest in fynbos, it had not been classified into structural or floristic units by 1979, when the reviews of fynbos ecology (Taylor, 1978; Kruger, 1979) were published. Campbell (1985, 1986a, 1986b) classified and described the vegetation of the mountains of the Fynbos Biome and it is this system which has been adopted for the Mountain Fynbos in this study. Fynbos is noted for its floristic complexity (Good, 1974; Kruger and Taylor, 1979), and this complexity lies at the heart of the reason why fynbos has yet to receive a detailed typological treatment three-quarters of a century after the first major attempt at a typology.

The vegetation of the Cape Floristic Region consists principally of fynbos, a broad category of diverse evergreen sclerophyllous shrublands that Acocks (1953) has called Macchia, False Macchia and Coastal Macchia. It also includes transitional veld types, Coastal Renosterbosveld

and Strandveld, that contain a mixture of Cape and other floristic elements. The veld types occurring within and adjacent to the Fynbos Biome include a variety of structural types and it is on this basis that Campbell *et al.* (1981) proposed a classification system.

Floristically, fynbos can be defined by two salient features: the lack of single species dominance, and the conspicuous presence of members of the family Restionaceae (Taylor, 1972). Physiognomically, fynbos is characterised by three elements; restioid, ericoid and proteoid. These elements comprise plants that resemble typical members of the Restionaceae, Ericaceae and Proteaceae in growth form, but do not necessarily belong to these families. The Restionaceae and some Cyperaceae, with their near-leafless tubular or wiry non-woody stems, give the vegetation its most characteristic physiognomic feature - the restioid element. The only other constant physiognomic feature, the small, narrow, often rolled leaves of some of the shrubs, is the ericoid element. Typical Cape plants representing the ericoid element belong to families such as Ericaceae, Rutaceae (*Agathosma*), Bruniaceae (*Brunia*), Polygalaceae (*Muraltia*), Thymelaeaceae (*Struthiola*), and to many species in genera like *Aspalathus, Cliffortia, Phylica, Metalasia* and *Stoebe*. Taller bushes with moderate-sized hard leaves, comprising the proteoid element, belong mainly to family Proteaceae eg. *Leucadendron, Leucospermum* and *Protea* (Taylor, 1978). In the broadest terms, the major vegetational subdivisions within the Cederberg region include Mountain Fynbos, (Taylor 1978; Campbell, 1985) and the Succulent Karoo Shrubland (Acocks, 1953; White, 1983; Moll *et al.*, 1984). These subdivisions are controlled primarily by the underlying substrate (geology) and not altitude, as found in the Central Karoo. There is however a moisture gradient from the Mountain Fynbos, which receives the highest rainfall, to the Succulent Karoo which has the lowest rainfall.

Of considerable interest biogeographically is the presence on these mountains of an endemic species of the Cupressaceae family, *Widdringtonia cedarbergensis*, the so-called Clanwilliam cedar (Manders, 1985) from which the Cederberg derives its name. Cedar patches consist of individuals or occasionally small groups of trees, typically forming open woodlands with an ericaceous understorey. Most cedar stands occur on the Peninsula Sandstone Formation, with some stands on the higher Nardouw Formation. In general, they are found on cliffs, rocky outcrops and very rocky slopes and not on the sandy flats between outcrops (Manders, 1986). The altitude range of the species is 1 050m to 1 650m with isolated specimens at lower altitudes. This threatened tree species is a significant component of this Mountain Fynbos, but is thought to have declined markedly in the recent past.

Plate 3.7 One of the few remaining stands of *Widdringtonia cedarbergensis* found on rocky outcrops on the Cederberg.

i. Mountain Fynbos.

Mountain Fynbos, the largest and most important unit of the Capensis vegetation, occurs in two blocks, a western and an eastern block. Part of the western block (Acocks' Macchia) occurs on the Cederberg Range, whereas the eastern block (Acocks' False Macchia) occurs on the Winterberg Range. Campbell (1985, 1986a) classified and described the vegetation of the mountains of the Fynbos Biome on the basis of vegetation structure. It is this classification system which is used to describe the local vegetation of the Cederberg Mountains.

a. Restioid Fynbos. This series is differentiated from the others by the high graminoid cover of restioids and sedges and a low cover of shrubs. Grassy Fynbos also has a high graminoid cover, but is the result of a high cover of grasses rather than restioids. Restioid Fynbos has the lowest constancy and cover of tall shrubs. Three sub-series of Restioid Fynbos are recognised: Azonal Restioid Fynbos which occupies deep rock-free soil and the highest rainfall regions; Mesic Restioid Fynbos and Dry Restioid Fynbos (Campbell, 1986a). Mesic Restioid Fynbos occurs at Driehoek and Sneeuberg Vleis.

b. Ericaceous Fynbos. Ericaceous Fynbos has a high cover of leptophyllous shrubs and restioids: the shrubs are ericoids of the Ericaceae. Other characteristic features are the high cover of Bruniaceae and the sedge component. Shrub cover and total cover are generally higher in this series than Asteraceous Fynbos. With regard to the soils, Ericaceous Fynbos occupies nutrient-poor mesic sites. In wet Ericaceous Fynbos, the soils are deep and organic, with a high silt content and may be waterlogged throughout the year due to local seepages.

c. Proteoid Fynbos. This series is differentiated from the others by having a cover of greater than 10% of mid-high to tall seed-regenerating proteoids. Four sub-series are

recognised: Mesotrophic Fynbos, Dry Proteoid Fynbos, Mesic Proteoid Fynbos and Wet Proteoid Fynbos. The dominant canopy species include *Protea laurifolia, P. repens, P. punctata* and *Leucadendron* spp (Campbell, 1985, 1986a). These soils, reaching depths of nearly 1m, tend to be less rocky and finer textured than non-proteoid soils. Proteoid Fynbos is found on the northern slopes of Driehoek Vlei.

d. Asteraceous Fynbos. Along the inner margin of the Cape Floristic Region there is a narrow band of Arid Fynbos (White, 1983) or Asteraceous Fynbos (Campbell, 1985), which forms the transition from typical Cape to typical Karoo vegetation. This vegetation community is found on the lower eastern slopes of the Cederberg. Although there are no rainfall figures available, this area is clearly in a rainshadow and it is thought that the rainfall is probably at the lower limit for fynbos. The low rainfall is the chief determinant of its most distinctive physiognomic feature - the open character of the vegetation.

In the Cederberg, Asteraceous Fynbos occurs on the undulating eastern slopes, encompassing Cederberg and Kromme River Farms. In this area, the boundary between Asteraceous Fynbos and karoo types is clearcut, coinciding with the contact between the Table Mountain and Bokkeveld Series at the base of a fault valley. Asteraceous Fynbos is usually confined to the Witteberg quartzites and the Karoo vegetation to Dwyka conglomerates. Marloth (1923) accounts for this distribution by explaining that fynbos plants cannot persist through the very dry summers of the inland fynbos fringe unless their roots penetrate deeply into rock fissures that store moisture. The quartzites have such fissures, but the Dwyka does not. The nutrient relations may, however, play an important part in the distribution of Asteraceous Fynbos.

Features which link Asteraceous Fynbos to non-Fynbos groups include the occasionally high cover of non-ericaceous

ericoids and low total cover (30-70%). Other features that link these two groups are the occasionally high cover of non-ericaceous ericoids, succulents and fleshy-leaved shrubs and the presence of broad leptophylls, deciduous shrubs and microphyllous geophytes (Campbell, 1985). Apart from the low total cover, Asteraceous Fynbos is further distinguished from other Mountain Fynbos types by a higher grass cover, elytropappoid cover and a higher non-ericaceous shrub cover relative to restioids and sedges. The shrub cover often consists of non-ericaceous shrubs from Thymelaeaceae, Asteraceae and Rhamnaceae. This series occupies the driest fynbos sites, where soils are shallow, rocky and have a higher clay content. It is found at lower altitudes and areas of lower rainfall where summer drought is more pronounced.

Four subseries of Asteraceous Fynbos are recognised, being: Dry Asteraceous Fynbos, Mesotrophic Asteraceous Fynbos, Oligotrophic Asteraceous Fynbos and Talus Asteraceous Fynbos. Talus Asteraceous Fynbos, which is easily distinguished by the presence of *Protea nitida* and a high grass cover, occurs on the eastern slopes of the Cederberg. Microphyllous non-proteoid shrubs and leafy sedges have a higher constancy in this sub-series than the other series.

ii. Succulent Karoo.

The succulent dwarf scrub formation is characteristic of the Western Cape Domain of the Karoo-Namib Region (Werger, 1978). This region, often referred to as the Tanqua Karoo, is enclosed by mountains which cut off the rain to the extent that the whole valley receives less than 150mm per annum, falling mostly in winter. In addition to the aridity, this area has been extensively trampled and has resulted in erosion down to bare shale in many parts (Acocks, 1953). The succulent Karoo shrubland is confined to the sandy soils of the Bokkeveld and the heavier stony soils on the foothills of these mountains. The plants range from almost subterranean species to shrubs 2m or more, with

the average height being between 0.3 and 1m. Large shrubs and bushes are virtually absent, except along rivers.

Adaptation to the dry climate is expressed in various forms of succulence, but also in other forms of xerophytism, including narrow or ericoid leaves, finely dissected leaves, hairy surfaces, sclerophylly, leaflessness for prolonged periods, desiccation-tolerant foliage, ephemerality and in the development of a dense cushion form. Adaptation to the windblown and shifting sands is particularly expressed in the cushion form of dwarf shrubs, a caespitose shrubby form in grasses, and the development of a life form transitional between hemicryptophytes and geophytes, which either possesses underground storage organs or a marked ability to form suckers. In the slightly moister areas, non-succulents do occur, for example *Stipagrostis obtusa*. Annuals and geophytes are numerous as regards species, but are rarely seen. The vegetation is dominated by short and stemless succulents or, following good rains, by annuals from the families Asteraceae and Brassicaceae. Genera such as *Ruschia, Sphalmanthus, Rhinephyllum, Drosanthemum, Hereroa, Psilocaulon, Mesembryanthemum, Galenia, Salsola, Euphorbia, Cotyledon, Crassula* and many others are evident (Werger, 1978).

3.7 CONCLUSION.

An understanding of the environmental and climatic conditions prevailing at the four sites along the east-west transect of the Karoo is necessary if the fluctuations in the vegetation in the past are to be understood. The semi-arid Karoo Region is complex, with a high degree of variability and extremes in both temperature and rainfall, particularly as one progresses west. Once the present vegetation distributions and their possible origins and affinities are understood, can past conditions be explained and interpreted. Modern biogeographic data are an important

source of information for historical reconstructions, but if a fuller appreciation of the dynamic evolution of the Karroid vegetation is to be gained, these data need to be complemented by fossil evidence, such as that from palynology.

An understanding of the contemporary vegetation patterns is essential for the interpretation of the fossil pollen data. There has been speculation with regard to the origin of the fynbos and the apparent movement of the western margin of the Karoo Biome. Asteraceous Fynbos islands are found to be separated from their nearest neighbours by many kilometres of Karoo vegetation of a different composition. This prompts the view that Asteraceous Fynbos of such situations is a relic vegetation. Marloth (1923) postulates that during the wetter and warmer Tertiary period, the Fynbos would have covered the inland plains and the mountains. With the onset of aridity, the mountain habitats provided the only retreat for Fynbos elements. The probability of such a migration or retreat is supported by Acocks (1953) who cites common genera in the non-succulent Karoo flora, like *Chrysocoma, Hermannia, Euryops* and *Pteronia,* that are also well represented in the Asteraceous Fynbos. This, together with the transition sometimes found between Asteraceous Fynbos and the Karoo vegetation, is seen as evidence for the past intermingling of these floras that must have occurred during periods of fluctuating rainfall (Taylor, 1978). The existence of vegetation on discrete islands could reflect the above type of fluctuations which are of interest in this palynological investigation.

The above postulations highlight the necessity for a continuous vegetation history of the western margin of the Karoo. Only when a continuous palynological record is available, showing the timing and extent of the vegetation changes, can the above-mentioned suggestions be examined.

CHAPTER 4

TECHNIQUES OF DATA COLLECTION AND ANALYSIS

4.1 INTRODUCTION.

Pollen analysis of Quaternary deposits is well established as a major technique used in the reconstruction of past environments and has numerous possible applications. Pollen analysis is by no means the only technique available for examining sediments, but in this investigation it is the most appropriate method of reconstructing the past vegetation. Other techniques, such as macrofossil analysis (Avery, 1984; Grindley and Grindley, 1987), diatom analysis (Gasse *et al.*, 1983), isotopic analyses (Vogel, 1983) and chemical analysis, also yield valuable results. The term "pollen" analysis may be misleading, for it is intended that it should include the identification of spores of Pteridophytes and Bryophytes, as well as pollen of Angiosperms and Gymnosperms (Jones and Cundill, 1978).

Quaternary pollen analysis has evolved rapidly with descriptive ecology. Before pollen analysis was used, peat stratigraphy was the main source of evidence for past changes in vegetation and climate in Europe. Layers of scarcely humified *Sphagnum* peat were taken as indicators of fast peat growth and, therefore, of wet climatic conditions. Layers of darker, more decomposed humified peat, often with a layer of tree stumps of Birch or Pine, were taken to represent a drier bog surface, and hence a drier, warmer climate. A climatic sequence emerged, often called the Blytt-Sernander scheme of climatic change (Birks and Birks, 1980). Although it was a useful method, more advanced and precise techniques have evolved. The recognition of pollen grains and spores as air-borne particles and microfossils in rocks and soils, dates back into the nineteenth century. It

was not until the early twentieth century that pollen was extracted from organic deposits, and the frequency of each different pollen type expressed in percentage terms to interpret past vegetation patterns. Lennart von Post, in 1916, was the earliest worker to utilise this technique and demonstrate that it was possible to trace the development of plant communities through time by plotting pollen frequencies in the form of a stratigraphic diagram. More recently, the use of pollen analysis has spread to many parts of the world and has led to an increase in detailed knowledge of past environments (Jones and Cundill, 1978).

Pollen analysis relies on the fact that all flowering plants produce pollen, whereas ferns and mosses produce spores. During the reproductive process, the flower is pollinated, thus dispersing the pollen. A feature of pollen grains and spores is that their pore structure and sculptured exine make them easily recognisable and this allows identification down to species level, although sometimes it is only possible to identify the genus from which it comes. Pollen taxonomy and reference material is organised, published and up-to-date in most areas, making the identification of pollen under the microscope fairly easy. Unfortunately, a complete pollen reference collection is not available for the southern African Flora, thus hampering the identification of fossil material.

The resistant outer casing or exine of the pollen grains and spores is composed mainly of sporopollenin, which is resistant to decay, particularly under anaerobic conditions. Sporopollenin is thought to be one of the most resistant organic materials of direct biological origin found in nature (Brooks and Shaw, 1978). The resistance of sporopollenins to microbiological, chemical and physical degradation permits the study of the morphology and microstructure of such palynomorphs and forms the basis of palynology. Pollen is best preserved in anaerobic organic sediments which are deposited in a stratigraphically logical

sequence. These include vlei or lake sediments, waterlogged acidic soils, marine sediments and peat bogs.

After sampling the pollen-rich organic sediments, the pollen assemblage is determined and used to reconstruct the past vegetation community of the catchment area. Within a stratigraphic sedimentological deposit, palynological studies show a successive sequence of pollen assemblages, which represent a broad picture of changing vegetation with time. The fossil pollen provides a record of the past vegetation, which in turn is interpreted as an indication of the general environment of the area. The scale at which this is done may range from a continental scale, down to a local scale, where mosaics of different communities may be established (Birks and Birks, 1980). This type of reconstruction has associated problems and usually only a general picture of the major habitats can be determined. The use of evidence from independent macrofossil studies augments the palynological data and usually improves the accuracy of historical plant geography.

An aspect of palynology which is of increasing importance in southern Africa is the relationship between the contemporary pollen spectra and the prevailing vegetation types. An understanding of the pollen/vegetation relationship is essential for the interpretation of fossil pollen assemblages, as it is the pollen actually arriving in the vleis and being deposited on the organic sediments that indicates the usefulness of fossil pollen analyses. This relationship has achieved a degree of mathematical precision in the temperate regions (Davis and Goodlett, 1960; Birks, 1977) and the tropics (Flenley, 1973). In southern Africa this pollen/vegetation relationship has been confirmed by Coetzee and Van Zinderen Bakker (1952) in the Orange Free State, Meadows (1984b) on the Nyika Plateau in Malawi and Meadows and Meadows (1988) on the Winterberg Escarpment.

Although pollen morphology is the most fundamental aspect of palynology, Quaternary pollen studies have been assisted in recent years by the use of numerical methods of analysis to aid in the zonation and interpretation of fossil pollen assemblages.

4.2 PRINCIPLES AND PROBLEMS OF POLLEN ANALYSIS.

4.2.1 PRINCIPLES OF POLLEN ANALYSIS.

Palynological studies have proved invaluable in the reconstruction of former environments, particularly environments of the Late Quaternary period (Meadows and Meadows, 1988). Today palynology is regarded as the principal technique used in the reconstruction of palaeoenvironments of the Quaternary period (Hamilton, 1982). Although pollen analysis has been developed and refined since its inception in 1916 by Lennart von Post, the basic method has remained the same.

The information from the pollen assemblages from sediment samples is used to reconstruct plant communities from terrestrial environments. Palynological studies of stratified sediments show sequences of pollen assemblages which present a broad picture of vegetation change with time (Birks and Birks, 1980). The scale for which the vegetation reconstruction occurs may vary from a small, local scale, where a mosaic of the different communities composing the vegetation may be detected, to a large scale, such as vegetational and hence climatic zones on a continental scale. The scale is dependent on the catchment area of the vlei and the number of sampling sites available. A detailed reconstruction of the vegetation does have a number of associated difficulties and, usually, only a general picture of the major assemblages can be determined. The basic principles of pollen analysis are outlined by Birks and Birks (1980).

The philosophical principle of palaeoecology is that of Uniformitarianism, ie.the ecology of an individual species remains constant through time. This is fundamental to palaeoecology, because without such a premise there would be no guarantee that the former vegetation communities which have been reconstructed would have any palaeoenvironmental significance. If the ecology of plant species is not thought of as being constant, or at least dynamic about the equilibrium, the changing distribution pattern of that species, as extrapolated from the pollen data, cannot be interpreted as an environmental indicator. Although the climate is thought to be expressed in vegetation changes, the amount of change may vary from region to region. In the past, there has been a tendency to over-rate the effects of climate on vegetation change. It is being increasingly realised that other influences such as edaphic and anthropogenic factors are also of significance to vegetation development, but have varying lag times which would influence the rate of vegetation development.

4.2.2 PROBLEMS ASSOCIATED WITH POLLEN ANALYSIS.

The basic assumptions of pollen analysis create difficulties for the palaeoecologist that are compounded by methodological and statistical problems. In the long series of events between the release of pollen from the anther to the final pollen diagram, much may happen to distort the record and make a pollen diagram misleading, unless the distortions can be compensated for.

i. Pollen Production.

One problem is that different types of plants have different pollen production and dispersal quantities. In general, wind-pollinated taxa produce much more pollen than insect-pollinated taxa, thus causing a bias in the pollen data obtained (Birks and Birks, 1980). This differential pollen production is apparent in the fynbos, where a large proportion of the taxa are entomophilous. Seasonal and

diurnal variation in the dispersal of pollen adds to the complexity of investigating fossil pollen grains (Hawke and Meadows, 1988; Hyde and Williams, 1955). Apart from the grains transported by insects or water, or expelled forcibly by some active process, pollen grains are dispersed in the atmosphere following the laws governing all small particles (Tauber, 1967).

Distinguishing between local swamp elements and the more distant regional or extralocal pollen (Janssen, 1967) in vlei sites is also problematic. It is usually necessary to separate the regional pollen as it is an indication of the surrounding vegetation changes, but this is complicated because certain palynomorph taxa are produced both locally and regionally. Contemporary pollen traps, surface samples and vegetation mapping should be used in conjunction with fossil pollen analyses to reduce this problem (Janssen, 1967; Meadows, 1984a; Scott, 1984).

ii. Pollen Dispersal.

The dispersal of pollen depends principally on atmospheric turbulence, windspeed and direction, weight and shape of pollen grains and the height and strength of the pollen source (Birks and Birks, 1980). The occurrence of long distance transport must also be borne in mind, particularly when interpreting pollen assemblages from environments with a low local pollen production (Maher, 1964).

iii. Pollen Preservation.

An additional problem is one of differential preservation of pollen (Havinga, 1964, 1967) and the availability of suitable preservation media. Physical, chemical and biological processes affect pollen grains from the moment they are liberated from the plant, and therefore they can be altered in various ways before being examined by the pollen analyst. The availability of suitable preservation media in the semi-arid Karroid environment is a problem, as waterlogged, anaerobic sediments are seldom found. Surface

samples taken for contemporary pollen studies may give a general indication of the relationship between the vegetation and the pollen being preserved in the top few centimetres of the soil.

iv. Identification.

Accurate identification and counting of the fossil pollen grains often causes problems. Even using a Zeiss light microscope, at a magnification of x1 000, there are some pollen types which can only be identified to family or genus level, for example, the important Poaceae family. The differentiation of C_3 and C_4 grasses has important implications with regard to identifying changes in temperature over time. However, it is not yet possible to distinguish them using the light microscope. The differentiation of *Stoebe* and *Elytropappus* also has important implications, as these genera are good indicators of environmental conditions in southern Africa, particularly *Stoebe*, which is more abundant in disturbed areas in the Karoo. Scanning electron microscopy has therefore been used to "iron out" some of the identification problems.

Until recently, most samples were counted using relative techniques, where a random sample of up to 500 grains was counted. The frequencies of the taxa are expressed as a percentage of the pollen sum. Absolute pollen counts are more informative than relative counts, as influx rates may be calculated and each taxon is independent and not influenced by fluctuations in the frequencies of associated taxa. Additional dates are awaited for the cores, which will facilitate the calculation of accurate pollen influx rates and render the absolute counts more useful.

v. Preparation Losses.

Methodological problems relating to the differential resistance of pollen taxa to acetolysation have been noted (Godwin, 1977). Unfortunately the composition and resistance of the exine to acetolysis differs in a few taxa,

therefore affecting the composition of the fossil pollen sample. The susceptibility of some taxa has been documented, for example Juncaceae (Van Zinderen Bakker, 1957) and Orchidaceae (Erdtman, 1969; H.P. Linder, pers.commun., 1988), but it is possible that there are other taxa which are not resistant to acetolysis and have not yet been documented, thus eliminating them from the fossil record during the chemical purification process. The effect of acetolysis on pollen grains is discussed by Faegri and Deuse (1960) and Godwin (1977), the most common problem being related to the enlargement or swelling of grains after acetolysis.

vi. Statistical Problems.

In essence, pollen analysis is a statistical technique, and as such it is subject to the rules that govern all statistical relations. The data obtained from pollen analysis are estimates of the "true" values. At the time of deposition, the pollen deposited in peat or sediments is a sample of the pollen produced in the area, and the grains preserved until the day of investigation again represent a sample of the original deposit. Further, the core of sediment taken for analysis represents only a sample of the total deposit, so at least three sampling procedures have preceded analysis, all with inherent sampling errors (Faegri and Iversen, 1975). Statistical errors therefore arise with regard to the representivity of the pollen sample which is eventually investigated on the microscope slide. Clearly, one cannot study all the sediments in the vlei or peat bog, but effort is concentrated on what is expected to be a representative core from a small area in space and time. The core is subsampled at 5cm intervals, each of which are once again subsampled for chemical purification. Once the pollen is concentrated, the pollen-silicone oil suspension is again subsampled and 0.02ml of the suspension is examined to give the final pollen frequency at that particular depth. This pollen assemblage is then interpreted as representative of the regional vegetation. The representivity of the final

pollen assemblage is therefore debatable. Surface samples are taken from the contemporary vleis and their pollen assemblage compared to the present vegetation of the vlei. The relationship appears to be very close, thus improving the validity of this technique. Meadows (1984b) and Meadows and Meadows (1988) found that surface peat samples from Nyika Plateau and the Winterberg yielded pollen spectra which accurately reflect the vegetation at a particular site.

Faegri (1966) has however commented that due to the nature of pollen analysis, absolute data cannot be obtained and should be regarded with suspicion, with great care being exercised in drawing conclusions from scanty data. Subsequent researchers (Davis, 1965, 1966; Peck, 1974; Birks and Birks, 1980; Birks and Gordon, 1985) have however, utilised absolute techniques to great advantage, with the absolute method now well established.

vii. Chronology and dating.

Dating of the sedimentological sequences also has its problems. Apart from the problem that deposits older than 30 000 to 40 000 years cannot be effectively dated using the carbon-14 method, a further problem is that the age determinations sometimes provide anomalous values (Scott, 1984). This is especially the case with spring peat sites in the relatively dry central parts of this country. It is believed that contamination of younger organic material, such as deeply penetrating minute rootlets, could be the main reason for the problem (Scott and Vogel, 1983). In some cases, particularly vlei sediments, the apparent anomalous values may not be due to contamination, but merely due to reworking of the sediment by burrowing animals within the vlei. This irregularity should be identified during examination of the sediment stratigraphy prior to pollen analysis and investigations in the field.

The palynological reconstruction of Quaternary environments in South Africa is usually based on comparisons of fossil pollen spectra with recent pollen spectra from different vegetation types and climatic regions. Hence, it is necessary to gain knowledge about the relationship between pollen spectra and various vegetation types. In this way, pollen spectra of the modern vegetation can be consulted to provide a means of estimating the nature of past conditions. Extensive contemporary pollen studies are therefore a necessity in any palynological investigation in southern Africa. That this priority has not previously been attended to in southern Africa is an undoubted constraint for palaeoecologists attempting to reconstruct Quaternary environments. A good understanding and knowledge of the contemporary pollen rain and associated pollen characteristics would therefore reduce the problems and errors related to differential production, dispersal and preservation of pollen.

4.3 POLLEN REFERENCE COLLECTION.

4.3.1 INTRODUCTION.

In Quaternary palaeoentology, the investigator accepts a pre-existing modern taxonomy as a standard, and attempts to identify the fossil pollen by comparison with the standard. If the fossil is similar to a taxonomic category of the modern reference material, but dissimilar to all the other categories, the name of the living taxon is applied to the fossil (Moore and Webb, 1978; Birks and Birks, 1980). The analyst attempts to match the pollen grains with those of modern taxa of the lowest possible rank, whose range of variation includes the fossil grains. It is sometimes possible to identify the grains to species level, but more often only generic rank is obtained. Successful identification depends on a variety of factors, one of these being the range of the reference material used. Variability

within genera and species should be represented in the reference material by having several specimen slides of each species, but from different localities. This should cover the range of its natural variability (Birks and Birks, 1980).

The greatest stumbling block in the analysis of fossil pollen and, in some cases, contemporary pollen studies in southern Africa, is the paucity of reference collections and pollen atlases to aid in the identification of pollen grains. The only pollen atlas for the southern African flora is the series by Van Zinderen Bakker (1953, 1956) and Van Zinderen Bakker and Coetzee (1959). Although an outstanding piece of work and a valuable contribution to South African palynology, all pollen grains are represented in diagrammatic form which is not as satisfactory as photographic representations. In addition, no complete pollen reference collection of the flora of southern Africa exists. The species diversity of the flora of southern Africa is exceptionally high, with a total of 24 030 taxa (including subspecies) being documented for the entire region (Gibbs Russell, 1984).

The task of establishing a pollen reference collection for the flora of southern Africa is immense and therefore regional collections have been established to fill this gap. Regional collections are available at the University of the Orange Free State in Bloemfontein, the South African Museum in Cape Town and Rhodes University in Grahamstown, none of which have a comprehensive collection of the flora of the Karoo Biome. Therefore, before any detailed palynological work and identification could be done in the Karoo, a reasonable reference collection of both microscope slides and photographs had to be made. The collection which was started at Rhodes University in 1985, contained 450 different species and focused on the flora of the Winterberg Escarpment. These slides were made under the supervision of Dr M.E. Meadows and formed the foundation of the present

collection, which represents species found in the Karoo and Fynbos Biomes, but specifically from the study areas discussed in Chapter 3.

4.3.2 POLLEN COLLECTION.

During all field excursions to the study areas, specimens of plants in flower within the vicinity of the study areas were collected, pressed, mounted and then donated to the appropriate herbarium. Due to the time constraints and identification problems involved in collecting specimens in the field, the majority of the type material was obtained from herbarium specimens from the Albany Herbarium in Grahamstown, Andries Vosloo Nature Reserve Herbarium near Grahamstown, Fort Hare Herbarium in Alice, Karoo National Park Herbarium in Beaufort West, Compton Herbarium (Kirstenbosch) and Bolus Herbarium in Cape Town. The preparation of reference slides from the Central and Eastern Karoo was undertaken during the first six months of 1986, while based at Rhodes University in Grahamstown. The expansion of the collection to include fynbos and western Karoo species was undertaken in 1987, while at the University of Cape Town. The expansion of this collection is an ongoing project and new specimens are continually being collected and reference slides made.

Grid-squared species lists for the four study areas were obtained from the Botanical Research Institute in Pretoria. These listed all the species which have been identified in each study area and formed the basis of the pollen types collected from the herbaria. At least one flower was taken from each herbarium specimen and herbarium sheets from which pollen has been taken were clearly labelled. Special care was taken to ensure that the herbarium specimen sampled had been identified by a well-known botanist and not from a student collection, thus reducing errors related to incorrect classification. Collectors' names and numbers, and the herbarium of origin of each specimen have been

recorded to enable researchers to refer back to any of the voucher specimens.

4.3.3. LABORATORY TECHNIQUES.

The slides of the reference collection should correspond as closely as possible to the grains met with in actual pollen analysis. This means that both the extra-exinous waxes of the entomophilous plants and the interior parts of the grains are removed, leaving only the exines. Adopting the same preparation procedure for both reference and fossil pollen facilitates comparison and identification. The aim of the sample preparation, staining and mounting is to concentrate the pollen grains and to make them as visible as possible (Faegri and Iversen, 1975). According to Erdtman (1943, 1969), clean permanent slides can only be made after acetolysis, as this renders the pollen grains translucent and the exine structure visible.

For the preparation of modern samples, the flower is treated with 10% NaOH, the stamens washed through a fine sieve and the humic acids removed. Next, extraneous matter is removed by acetolysis and the pollen stained with safranine before mounting in either glycerine jelly or DPX mountant. The mounting procedure adopted is a modified version of those devised by A. Scholtz at the South African Museum (Cape Town) and Dr D. Livingstone's Palynology Unit at Duke University, N.C., U.S.A. Both of these techniques are essentially based on Erdtman's (1943) method. The mounting method devised by Scholtz (pers.commun., 1986) is simplified by omitting the use of plastic cubes, as it was found that, provided there was sufficient wax on the slide, this was not entirely necessary. Problems were encountered when heating the glycerine jelly and paraffin wax to melt it and seal the coverslip. Air bubbles which obscure detail often resulted from overheating the slides. With much practice and by heating the hotplate to a maximum of 45^{0}C, this mounting technique was perfected.

An alternative method of mounting the pollen was adopted in 1988, using DPX mountant (Method B of Appendix A). According to work done by Dr M. Zavada of the Botany Department at the University of the Witwatersrand, the life-span of the slides mounted in glycerine jelly is limited, as they are seldom still air-tight after 10 years and therefore the pollen grains are slowly destroyed by oxidation (M. Zavada, pers.commun., 1988). This method has been adopted in preference to the glycerine jelly method, as it is simpler, less time consuming, avoids problems relating to overheating and the slides have a longer life-span as they remain air-tight. The other inherent problem with the use of glycerine jelly is that the grains tend to swell (Faegri and Deuse, 1960; personal observation). The refractive index of DPX mountant (BDH Chemicals) is slightly higher than that of glycerine jelly (GER Chemicals), ie. from 1.515 to 1.525 and 1.473 to 1.410 respectively (Merck and Schuchardt, 1987; C. Gribbel, pers.commun., 1989). This affects the sharpness of focus of the photomicrographs taken using the light microscope. The variability encountered when using DPX mountant is compensated for by using an immersion oil of a slightly lower density to account for the differential refraction of light.

Staining is used, as it renders the pollen more recognisable and contributes to the differentiation of grains. Too much stain obscures the finer structural details of the exine of the pollen grain and it is therefore better to have the pollen grains too lightly stained than over-stained. One drop of safranine is usually recommended for a 10ml sample (L.P. Burney, pers.commun., 1988).

Appendix A outlines the basic procedure used to purify and mount the reference slides. The resistance of the pollen exine differs from one taxon to the next. Therefore, before filing the slides, they are checked and taxa not resistant to acetolysis identified (viz. Juncaceae and Orchidaceae) and re-mounted using unacetolysed pollen. Each slide in the

collection is appropriately labelled with the standard species number (Gibbs Russell, 1984), family, species name, place of origin of the specimen and the date of mounting. All the slides are catalogued according to their Gibbs Russell species number, which corresponds to the catalogue system used in most herbaria in South Africa. Problems have however arisen with the inclusion of species obtained from Central Africa and the Northern Hemisphere in this collection. These species are not indigenous to South Africa, and are therefore not included in the Gibbs Russell numerical system. In these circumstances, only the generic number is given to the reference slide.

4.3.4 SUMMARY.

The pollen reference collection now includes species from an extensive area: from the Winterberg in the eastern Cape, across the Great Karoo, Little Karoo, Tanqua Karoo and extending into the Mountain Fynbos in the Fynbos Biome. The expansion of the reference collection is an ongoing project and, to date has a total of 3 501 slides in the slide reference collection and 1 468 photographs in the accompanying photograph reference collection (Appendix F). Five copies of each reference slide are made, which enables the exchange of duplicates with other palynological centres throughout the world. 311 slides of different species, particularly from the Central African Flora, have been obtained from Dr D. Livingstone's Palynology Laboratory at Duke University, NC., U.S.A., while 24 were obtained from the Albany Museum in Grahamstown. One slide of each species is given to the Cape Town Collection of Pollen (C.T.C.P.), which has recently been initiated by interested palynologists and botanists at the University of Cape Town, the Bolus Herbarium and the South African Museum (Cape Town). This collection has been started in an attempt to build up a pollen reference collection of the Flora of southern Africa.

4.4 CONTEMPORARY POLLEN ANALYSIS.

4.4.1 INTRODUCTION.

The fundamental assumption of pollen analysis is that pollen rain reflects the vegetation type which produces it. The precise relationship between pollen rain and plant species abundance is complex and therefore contemporary pollen studies are essential in attempting to increase the present understanding and interpretation of this relationship. In general, an abundance of pollen of a particular taxon indicates the abundance of the plant taxon in the catchment area. Meadows (1984b) in his study of the Nyika Plateau in Malawi, found a strong relationship between the pollen rain characteristics and the vegetation producing the pollen. He found it to be true for both pollen traps and surface samples.

In order to support the results from fossil pollen analysis, an investigation of the contemporary pollen rain of the study area is essential. The relationship between the present day spectra and the vegetation which produces it is important, since it is this relationship between present day pollen rain and the pollen actually arriving in the vleis and becoming enmeshed and preserved in the peat that indicates the usefulness of the fossil data (Flenley, 1979b).

The reconstruction of past communities from pollen analysis is usually indirect, using one or more of the following methods:

i. The statistical approach leading to the delimitation of recurrent groups.
ii. The application backwards in time of known ecological preferences of taxa, thus using contemporary indicator species.
iii. The comparison of fossil pollen spectra with modern pollen spectra from known vegetation types.

These approaches depend upon finding modern analogues so that the present can be extrapolated back into the past, ie. methodological uniformitarianism (Birks and Birks, 1980). This comparative approach involves the characterisation of a range of modern vegetation types by means of contemporary pollen spectra, from both surface samples and natural or artificial pollen traps, followed by the comparison of these spectra with fossil pollen spectra.

North American palaeoecologists (Birks, 1976, 1977; Davis and Webb, 1975; Janssen, 1967; Webb, 1974) were the first to recognise that a thorough knowledge of former vegetation assemblages could be improved by the investigation of contemporary pollen spectra from natural or artificial pollen traps and surface samples. The early contribution of Davis and Goodlett (1960) to the study of pollen production, dispersal, sedimentation and preservation and later, the developments by Davis and Webb (1975) and Webb and McAndrews (1976) in North America, Anderson (1973) and Cundill (1986) in Europe, Hamilton (1976, 1982), Hamilton and Perrott (1980) and Meadows (1984b) in Central Africa, have increased our understanding of the relationships between pollen spectra and the vegetation. Most statistical analyses (Birks and Birks, 1980; Liu and Lam, 1985) demonstrate a remarkably close relationship between the present day spectra and the vegetation producing it, especially if differential productivity is taken into account.

Unfortunately very little information on the modern pollen rain produced by different vegetation assemblages is available for southern Africa, particularly in the Karoo. Modern pollen spectra have been described by Van Zinderen Bakker (1955, 1957), Thiergart *et al.* (1962), Coetzee (1967), Martin (1968), Schalke (1973), Scott (1982a, 1982b, 1983) and Meadows and Meadows (1988), but it is difficult to assess how representative southern African pollen is on the basis of these few studies. Van Zinderen Bakker (1987) comments that an assessment of the present pollen deposition

in the different parts of the Karoo is essential for the explanation of fossil pollen spectra.

Due to the paucity of contemporary pollen data in southern Africa, an extensive contemporary pollen rain programme was initiated in the study areas using techniques identical to those employed by Meadows and Meadows (1988) in the eastern Cape. In addition, surface samples were taken at the base of each pollen trap and at the coring site, obtaining the pollen spectrum from a "natural" pollen trap. The differences between the pollen frequencies in these pollen traps can then be examined. The contemporary pollen data is important for differentiation of the regional and local pollen spectra in the fossil pollen spectra. The regional pollen spectrum represents the vegetation from the surrounding catchment area, whereas the local pollen spectrum is representative of the vlei environment.

4.4.2 METHODS OF EXAMINING POLLEN RAIN.

Two main approaches have been used for the contemporary pollen study: the analysis of superficial sediment and soil samples, and the trapping of airborne pollen and spores in specially constructed pollen traps. The surface samples represent the accumulation of pollen rain over one or several seasons. Unfortunately this pollen is usually poorly preserved, because the arid conditions of the Karoo soils are not ideal for the preservation of pollen grains. Pollen traps on the other hand, should be used for at least a year before the data obtained from them can be used to interpret fossil assemblages (Moore and Webb, 1978). Although Meadows (1984b) and Hamilton (1976), in their Central African studies, only placed the pollen traps in the field for up to six months, the seasonality in the Karoo is far more pronounced and therefore data from all four seasons are necessary to give a complete record of the prevailing pollen rain in each vegetation assemblage.

The data collection procedure is fairly simple and involves the collection of a surface sample at the base of each pollen trap, in each contemporary vegetation community. This yields an integrated picture of contemporary pollen rain over the past few seasons, with some of the grains being older than others, resulting in a rather blurred pollen/vegetation relationship. In addition, 35 pollen traps identical to those used by Meadows and Meadows (1988) (Figure 4.1), were placed in each of the vegetation communities in each of the study areas. Due to the prevalence of the dwarf, Karroid-type vegetation and the abundance of entomophilous species, pollen traps were set on wooden stakes 1m above ground level and another trap placed at ground level (Plate 4.1). The pollen traps in each study area were collected and replaced annually. Replication of the data is necessary to increase accuracy and minimise seasonal or atypical annual fluctuations.

All fieldwork pertaining to the Eastern Karoo (viz. Winterberg, Sneeuberg and Nuweveldberg) was undertaken in the first seven months of 1986, while at Rhodes University. Cores were taken from the Cederberg sites in January and June of 1987 and again in January of 1988, while at the University of Cape Town. Fieldtrips in January of each year, were undertaken to collect and replace contemporary pollen traps. All laboratory preparations were undertaken in the Geography Department's Soils Laboratory, Rhodes University in 1986, and then in the newly established Palynology Laboratory in the Department of Environmental and Geographical Science at the University of Cape Town in 1987, 1988 and 1989.

Plate 4.1 Contemporary pollen traps in the Cederberg.

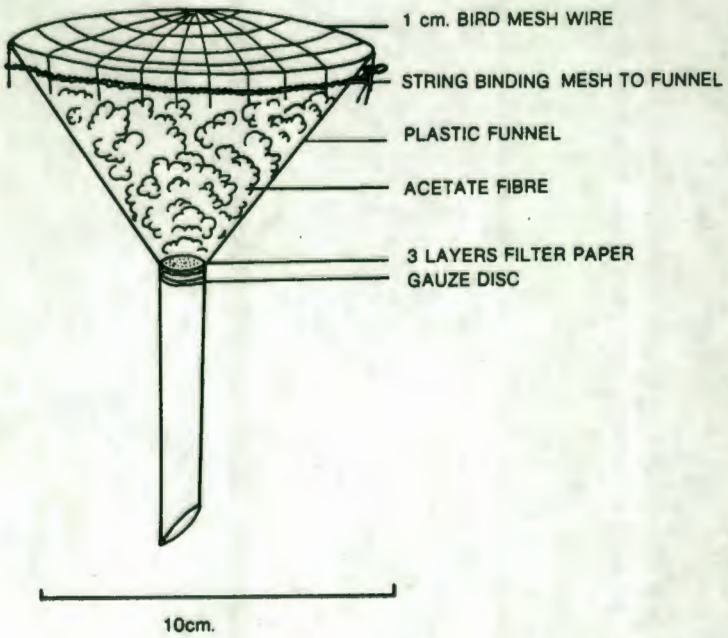

Figure 4.1 A pollen trap, used to collect contemporary pollen rain samples. This trap is tied to a stake 1m above the ground and another placed at ground level.

4.4.3 LABORATORY TECHNIQUES.

The techniques used for the purification of contemporary pollen are based on the same principles as those for fossil pollen analysis (Faegri and Iversen, 1975; Erdtman,1969). The aim of sample preparation, purification, staining and mounting is to concentrate the pollen grains and spores, and make them more visible for identification and counting. The technique involves removing humic acids with sodium hydroxide, removing silica using hydrofluoric acid, removing extraneous matter by acetolysis, staining the pollen grains and then mounting or storing in silicone oil. Most laboratory procedures have been adapted from techniques devised for material in the temperate areas of Europe and America. These procedures have therefore been adjusted slightly to suit the type of material obtained from the arid conditions in southern Africa.

The preparation of surface samples follows the above-mentioned procedure (see Appendix B for the detailed procedure), but the digestion of silica by hydrofluoric acid usually takes more than three hours. This is due to the greater proportion of sand in relation to humus and litter within the surface soil samples. Purification of pollen trap samples also follows the above-mentioned procedure (Appendix C), but is adapted to separate the acetate fibre from the pollen grains (Meadows, 1984b). The acetate fibre is dried and then dissolved in acetone overnight. The acetone is evaporated before continuing with the traditional purification and concentration of the pollen rain sample. Relative pollen frequencies are recorded in preference to absolute pollen counts which have been undertaken for the fossil pollen samples. All identification and counting has been done using a Zeiss photomicroscope (Standard Lab 16-8055), at a magnification of x630 (oil immersion).

4.4.4 SUMMARY.

In Quaternary palaeoecology, the investigator accepts a pre-existing modern taxonomy as a standard and attempts to identify the microfossils by comparison with this standard (Birks and Birks, 1980). The contemporary pollen rain programme therefore forms an essential part of any study which attempts to elucidate the vegetation history of an area. Only when one has an idea of the relationship between the present day pollen spectra and the vegetation actually producing it, can the pollen diagrams be interpreted in a meaningful way. This extensive sampling of contemporary pollen rain is undertaken to place the fossil pollen in the context of modern Karoo plant communities.

Contamination of the acetate fibre within the pollen traps, due to the defecation by birds caused problems. Contamination was accounted for by analysing the "bird droppings" separately and assuming that the difference between the contaminated samples and the "bird droppings" represented the pollen rain from the surrounding vegetation. Another minor problem encountered was the removal of acetate fibre from 5% of the funnels by birds. This problem is overcome by covering the funnels with a fine chicken-mesh or gauze. Fortunately, missing data from the 1987 data set were obtained from the replication of the 1988 data set. The contemporary pollen rain study will not only prove useful in identifying the pollen/vegetation relationship, but will enable modern analogue communities to be identified in the fossil pollen spectra and hence strengthen conclusions from the fossil analysis.

4.5 FOSSIL POLLEN ANALYSIS.

4.5.1 INTRODUCTION.

The objective of fossil pollen studies is to attempt to reconstruct the vegetation patterns in a chosen area over

time, in this case the late Pleistocene and Holocene periods. The degree to which the vegetation can be reconstructed is dependent on a number of factors including: the availability of sites suitable for the accumulation of pollen-rich sediments; the preservation state of the fossil pollen; and the techniques employed to obtain and purify the sediment samples. Pollen grains are best preserved in anaerobic conditions in waterlogged vleis and peat bogs. The vleis investigated include Ellerslie, Compassberg, Bokkraal, Driehoek and Sneeuberg, all of which were sampled for fossil pollen.

4.5.2 FIELD TECHNIQUES.

The technique of pollen analysis has two different aspects: fieldwork and laboratory work, and unless both are carried out with the greatest care, the results will be spurious or inaccurate. The aim of the fieldwork is to collect the uncontaminated samples from the deposit, to define as precisely as possible the conditions under which the samples were taken, to determine the types of sediment and to describe the stratigraphy.

Locating suitable organic-rich vleis was problematic, as few vleis exist in the Karoo. Reconnaissance trips were undertaken to locate and sample the most suitable coring sites on each mountain range. The criteria for choosing particular sites are as follows:

i. Accessibility of the site and within reasonable distance of laboratory facilities.
ii. Minimal disturbance of vleis by farmers or burrowing fauna.
iii. Suitable organic material and a high pollen content.
iv. Size and nature of the vlei eg. waterlogged vlei large enough for representative sampling.
v. Co-operation of owner or administrator of the land.

It is necessary to acquire some knowledge of the matrix from which pollen grains are recovered in order to evaluate the results. A number of factors are important in this context and should be noted. Firstly, plants which form the vlei or depositional environment have a pollen production of their own. This is referred to as the local production and is usually isolated from the more representative regional pollen assemblage of the surrounding environment. Secondly, the physical and chemical characteristics of a deposit influence the preservation state of pollen grains and spores (Cushing, 1967). Finally, an understanding of the plant communities trapping sediments and forming deposits can be useful in the interpretation of palaeoclimates.

When interpreting pollen diagrams it is important to assess the distance between the source and depositional area for different vegetation types, so as to eliminate problems related to over-representation and long-distance dispersal. Janssen (1967, 1973) and Prentice (1985) have identified four pollen elements which are derived from plants growing in different positions relative to the sampling site.

a. The local element is derived from plants growing in the vlei and up to 20m from its margins. The local elements, due to the plants growing within the vlei, are not consistent indicators of climatic changes as these plants (hydrophytes) are usually less responsive to external (macro-climatic) change in moisture conditions than the terrestrial plants.
b. The extra-local element is derived from plants growing between 20m and 2km from the vlei environment.
c. The regional element incorporates plants growing within 2 and 200km from the vlei basin.
d. The extra-regional element is derived from plants growing outside a 200km radius of the vlei. This long-distance element originates from a wide variety of sources and therefore only gives a general picture of the vegetation.

All the vleis sampled have the common characteristic of having sediments stratified in a sequence which bears some relationship with time. Samples are therefore collected in such a manner that the chronological stratified sequence is maintained. A number of instruments have been developed for the recovery of cores with minimum disturbance. A Dutch-manufactured, open-chamber gouge auger, with extension rods to a maximum of 6m, was used at all the sites to extract the sediment cores. Coring was initially attempted in the Winterberg using a Hiller auger, which is a closable-chamber corer in which contamination is minimal (Moore and Webb, 1978). However, the sediments from the Karoo vleis proved to be relatively dry and have organic contents ranging from 10 to 20%, which made coring with a Hiller auger unsuitable and in some cases impossible. The single steel gouge auger is thinner (30mm diameter) than the Hiller auger, designed for sediments of minimal penetration resistance eg. marshlands and soft clay soils, and to take undisturbed soil samples by a simple and fast method (Anon, 1984). This auger consists of a 1m long steel cylinder, which is open for about one third of its circumference and with a slightly sharpened cutting edge. This corer proved to be suitable for the extraction of polleniferous material in a stratigraphically logical order.

The gouge auger is an end-filling type, which works best in homogenous, fine-grained sediments, from which it gives a cleaner sediment core than the Hiller type. The one disadvantage of the gouge auger is that the top of the core travels the length of the sampling chamber, which is one metre, and therefore if material has adhered to the inside, contamination in the outer layer of the core may occur. Moreover, once the sample has occupied the chamber and is being brought to the surface, that part of the sample which is in the open part of the cylinder is unprotected from contact with the walls of the borehole and as a result, is prone to distortion and contamination with foreign pollen. Careful sampling is needed to reduce this problem, and means

that any part of the core which has been in contact with either walls of the auger or the walls of the borehole on retrievals, has to be diligently removed. Care must be taken to subsample from the centre of the core and the surrounding sediment is discarded.

The approximate centre of the vlei was chosen as the sampling site in all of the vleis. Exploratory cores were taken at random in the vlei to determine the deepest part and to get an idea of the vlei morphology. Cores varying in length, from 1m at Bokkraal Vlei, to about 5m at Driehoek Vlei, were extracted (Plate 4.2). Fragments of bedrock were usually found at the base of the cores, forming an impenetrable layer which was assumed to be the base of the vlei or swamp. The cores were extracted, wrapped and sealed in black plastic sheeting and taken to the laboratory for further analyses (Plate 4.3). The cores were subsampled at 5cm intervals and these samples stored in sealed glass vials in the refrigerator prior to analysis. Additional cores were extracted and larger samples of up to 400g were taken at the base and at intermediate depths, which are associated with the different sediment layers. These samples were sent to the National Physical Research Laboratory of the CSIR in Pretoria for radiocarbon dating. Although depth is a function of time, the relationship between the two may not be a simple linear one and, therefore, the more radiocarbon dates one can get, the more accurate the interpretation of temporal changes.

4.5.3 LABORATORY TECHNIQUES.

The aim of the pollen preparation technique is to produce a suspension of fossil pollen with as little matrix of extraneous materials, plant debris and silica as possible, in order to obtain a clear view of the grains. Most techniques have a common basis, although modifications are made from worker to worker through time, in the light of experience and advances in methodology (Kummel and Raup,

Plate 4.2 Coring using the gouge auger.

Plate 4.3 The gouge auger and cores, which are sealed and returned to the laboratory.

1965; Erdtman, 1969; Faegri and Iversen, 1975; Jones and Cundill, 1978; Moore and Webb, 1978). The basic technique used for fossil pollen analysis is to deflocculate the sediment with sodium hydroxide, remove humic acids, remove free calcium carbonate using hydrochloric acid, remove silica by digestion with hydrofluoric acid, remove cellulose and extraneous matter by acetolysis, stain with safranine and mount in silicone oil. Appendix D gives the detailed preparation technique employed.

Absolute pollen extraction techniques have been used in preference to relative counts. Absolute counts provide a means of estimating the density of the pollen type within a known volume of sediment. The absolute method allows for easier interpretation of results as percentages of fossil pollen grains are independent of each other. Fluctuation in the frequency of one taxon does not cause an associated change in other taxa, as found with relative counting techniques. A major problem with the relative technique previously employed, is that pollen types with high frequencies tend to suppress those with lower frequencies. A large increase in one of the dominant pollen types may suppress the apparent frequencies of all other types, although these may have undergone no real reduction. Misinterpretation may result and, as a result, absolute counting techniques have been employed where all the pollen grains of a known volume of sediment are identified, counted and included in the pollen sum. The pollen sum includes all pollen, spores, unknowns and unidentifiables (broken and corroded) and the percentage for each taxon is computed for each sampled depth. This frequency is plotted against depth on the pollen diagram. When radiocarbon dates are available, the rate of accumulation of sediment can be combined with a measure of pollen concentration within it, giving a figure for pollen influx, expressed in grains. $cm^{-2}.year^{-1}$.

The method for the determination of pollen concentration falls into two main groups: the direct methods, in which a known aliquot of the total assemblage is sampled by taking a known volume of sample and counting all the grains in the sample; and the indirect method which relies on the introduction of a known concentration of exotic pollen into a measured quantity of the purified sediment sample. The fossil grains are related to the total count of the exotic type. The direct methods include volumetric techniques (Davis and Deevey, 1964; Davis, 1965,1966) and weighing techniques (Jorgenson, 1967), whereas indirect methods include techniques in which an exotic marker grain is added to known volumes of sediment (Benninghof, 1962; Matthews, 1969; Bonny, 1972). According to Peck (1974), the extra time needed in preparation of the Davis and modified Jorgenson methods is balanced by a greater reliability of results.

After purifying the sample, the pollen is mounted in silicone oil. This mounting medium was selected above other media because the slides last well, as long as the pollen has been thoroughly dehydrated. In addition, the grains hardly alter in size over time (Birks and Birks, 1980). Glycerol and glycerine jelly are also common mounting media, but pollen life is short and the latter causes swelling of the pollen grains.

All identification and counting was done using a Zeiss light microscope (Standard Lab 16-8055) at a magnification of x640. Counting was carried out along regular traverses of the microscope slide, until the entire sample had been counted. Problems were encountered due to the differential resistance of pollen grains to acetolysis. Unfortunately, Orchidaceae and Juncaceae are not resistant to acetolysis and therefore the fossil pollen is usually badly corroded and seldom identifiable. This problem was, in part, overcome by making unacetolysed reference slides of these taxa and scanning the fossil samples prior to acetolysis.

Fortunately these families are not dominant components of the vegetation in the study areas.

In addition to the palynological data, the geomorphological evidence pertaining to the stratigraphy of the sediments should be investigated. A stratigraphic vlei sequence offers an important source of information on the processes acting upon the vlei during its formation and development through time (Dewey, 1988; Meadows, 1985a). Particle size analysis of the sediment at different depths was conducted using the simple dry sieving technique (Smith and Atkinson, 1975; Briggs, 1977). Although a number of methods for particle size determination have been devised, the best known methods include the pipette method (British Standards Institute {BSI}, 1975), the hydrometer method (BSI, 1975) and the sieving technique. The quickest and simplest method, the sieving technique, was used.

The organic content of the sediment was determined at different depths in each core. The organic matter content of soils reflects the balance between production of litter and decay and is a function of temperature, rainfall regimes, hydrology, nutrient status, nature of the landuse and its management. The more rapidly decompositon occurs, the more efficient the mineralisation process and the lower the carbon-nitrogen ratio. The Walkley-Black technique (Smith and Atkinson, 1975) was used in preference to the ignition or dry combustion method, as the former was more accurate and suitable for the determination of organic matter within these vlei sediments. The loss-in-weight principle of the ignition method suffers from being non-specific and provides an index of organic matter content rather than a meaningful absolute value. The reduction in heating in the Walkley-Black method differentiates soil humus from extraneous sources of organic carbon, such as graphite and charcoal, which is a distinct advantage of this technique (Jackson, 1958).

In the Walkley-Black technique, the soil is digested with a mixture of chromic and sulphuric acids, utilising the latter's heat of dilution. Organic carbon is converted to carbon dioxide by the chromic acid, which is thereby reduced to chromic sulphate. Since the amount of chromic acid consumed is proportional to the amount of organic matter in the soil, it is possible to determine the former by titrating the unreacted excess of chromic acid with a standard ferrous solution. The procedure used (Appendix E) is adapted from Smith and Atkinson (1975) and BSI (1975). Sediment samples from each major stratigraphic sequence in each core are taken for the determination of their organic content.

4.5.4 SUMMARY.

Absolute counts for all core samples were calculated and used together with sedimentological data and radiocarbon dates, to construct the detailed pollen diagrams. Problems were encountered with critical identifications of a few taxa and therefore scanning electron microscopy was undertaken to "iron out" these problems.

4.6 SCANNING ELECTRON MICROSCOPY.

4.6.1 INTRODUCTION.

The scanning electron microscope has proved to be an extremely useful tool for palynologists as it enables more accurate identification of pollen types. This leads to a higher degree of resolution and precision in the examination of past environments. In the identification of fossil pollen grains from deposits, the scanning electron microscope has a more limited use, because it is not possible to count or obtain frequencies of taxa as one does using the light microscope. Many identifications depend on structural details of the pollen exine which may not be

visible in surface view, and it is impossible to re-orientate the pollen on a prepared stub, thus limiting its use for counting fossil pollen types.

According to Ladd (1977) and Kohler and Lange (1979), a much higher degree of reliability in the identification of the pollen types may be achieved using the scanning electron microscope. Ladd (1977), in a study of Restionaceae pollen, comments that it is almost impossible to distinguish the microverrucae, the exine structure and, in many cases, the puncta with a light microscope. Linder (1984) has used the scanning electron microscope (SEM), transmission electron microscope (TEM) and light microscope (LM) to classify the genera of the African Restionaceae as they complement each other. These three methods are complementary, with TEM being most useful for critical identifications of fossil palynomorphs (Coetzee and Muller, 1983). Once the critical identifications are made, the correct information may be related to the rest of the sample.

In this project all identifications and counting of fossil and contemporary pollen samples have been done using the Zeiss photomicroscope. Identification problems were encountered with a few taxa which, under the light microscope, are remarkably similar. The SEM investigations are undertaken to augment the LM investigations and to examine the diagnostic features of the selected "problem" taxa. Fossil pollen is usually identified down to family level but in some cases identification to genus level is required, particularly with regard to "indicator" taxa, for example *Stoebe* and *Elytropappus*.

4.6.2 METHODS OF EXAMINING POLLEN GRAINS.

The following taxa are examined using the scanning electron microscope. All vouchers are from Bolus Herbarium.

Family	Species	Vouchers.
Amaranthaceae :	Amaranthus thunbergii Moq.	Salter 9012
Asteraceae :	Stoebe vulgaris Levyns	Schelpe 558
:	S.aethiopica L.	Esterhuysen 3702
:	Elytropappus rhinocerotis (L.F.)Less	Levyns 10555
Caryophyllaceae:	Dianthus albens Ait.	M.A. Pocock 3093
Chenopodiaceae :	Chenopodium abrosioides L.	Bingham 886
Ericaceae :	Erica acuta Andr.	M.R.Levyns 10017
Fabaceae :	Aspalathus spinosa L.	R.Dyer 1273
Poaceae :	Pentameris macrocalycina (Steud.)Schweick.	Pillans 11990
Proteaceae :	Diastella divaricata (Berg)Rourke	Guthrie 104
Restionaceae :	Restio filiformis Pior.	Rogers 5292
:	Ischyrolepis sieberi (Kunth) Linder	Esterhuysen 30179
Rhamnaceae :	Phylica gracilis D.Dietr.	Burman 864
Rubiaceae :	Anthospermum aethiopicum L.	Pillans 7432
Rutaceae :	Agathosma bifida (Jacq.) Bartl.& Wendl.	Stokoe 66997

Problems were associated with distinguishing similar taxa from one another, viz. Restionaceae and Poaceae; Chenopodiaceae , Amaranthaceae and Caryophyllaceae; *Stoebe* and *Elytropappus*. The remaining taxa were examined in an attempt to gain knowledge of the structure and diagnostic features of the particular taxon. The species examined were chosen as they are characteristic of their family with regard to morphological features and in this way thought to be representative.

The preparation procedure used for these samples involved the collection of herbarium specimens, mounting and coating, prior to viewing on the SEM. Using a dissecting microscope, the anthers are isolated, air-dried and the pollen dusted onto a stub, which is lightly coated with a mixture of

graphite powder and an aqueous glue specified by the Electron Microscope Unit at the University of Cape Town (D. Gerneke, pers.commun., 1988). The specimen is then coated with gold-palladium and examined. Preparation of the material and SEM investigations were undertaken in the Electron Microscope Unit at the University of Cape Town. All examinations were made using the Cambridge S200 Scanning Electron Microscope. The preservation state of pollen grains varies according to the type of treatment they undergo prior to examination in the SEM, ie. unacetolysed, dehydrated grains collapse whereas acetolysed hydrated grains are rounded and full (Blackmore and Barnes, 1984). Untreated, unacetolysed pollen grains which were not subjected to critical-point drying were used in all the SEM investigation, whereas acetolysed herbarium specimens were used for LM investigations.

This SEM study was an exploratory investigation of the techniques available and the less elaborate preparatory procedures, were followed. The merits of the different procedures are discussed by Köhler and Lange (1979), Lynch and Webster (1975), Postek *et al.* (1980) and Velari (1984).

4.7. STATISTICAL ANALYSES.

4.7.1 INTRODUCTION.

The introduction of numerical and computational methods in the analysis and presentation of palynological data (Gordon and Birks, 1972, 1974; Birks and Deacon, 1973; Birks, 1974; Birks and Birks, 1980; Birks and Peglar, 1980; Scott, 1982b; Birks and Gordon, 1985; Clark *et al.*, 1986) is one of the new directions of development in pollen analysis. The complexity of the statistical methods vary greatly and depends on the type of data available and the problem being investigated. A variety of statistical analyses have been used (multiple discriminant analysis, factor analysis and

TWISA) in an attempt to select the most appropriate technique to assist in the interpretation of past vegetation assemblages.

Statistical treatment initially involves the production of a pollen diagram, which shows a plot of the pollen types against sediment depth. Using radiocarbon dating, the depth of the sediment is used as a surrogate for the age of the sediment. Families are arranged in groups, beginning with spores and graminoid-types, followed by herbs, shrubs and finally arboreal taxa. All pollen and spore types which have originated in the local and regional environment are included in the pollen sum and are expressed as a percentage of this sum. The unknown and unidentifiable pollen grains are not part of the pollen sum, but are represented on the pollen diagrams.

To facilitate interpretation of the pollen diagram, local vegetation is distinguished from regional and extralocal vegetation. Taxa representative of the local environment are extrapolated from surface sample spectra, pollen trap spectra and on-site vegetation mapping. Taxa occurring in the present vlei or swamp environment and ecologically known to be hydrophytic or "vlei" taxa, are taken as representative of the local environment. These taxa are represented in the contemporary samples from the vlei. Taxa found in pollen traps and surface samples from immediately adjacent upland areas (extralocal vegetation) and regional areas (Janssen, 1967) are representative of the regional environment. Throughout this manuscript, the term regional vegetation is used to refer to both the regional and extralocal vegetation.

Once the detailed pollen diagrams have been constructed, it is usual practice to divide the diagram into pollen zones to simplify the discussion of the sequence of vegetation changes which have occurred. The pollen zone is defined by Gordon and Birks (1974) as "a body of sediment with a

consistent and homogenous fossil pollen and spore content that is distinguished from adjacent sediment bodies by differences in the kind and frequencies of its contained fossil pollen and spores." (p.962). Zonation of the pollen diagram is initially based on a visual, subjective classification and then substantiated using objective, statistical analyses. In general, computer methods tend to give results which agree with the zonation done by eye and any discrepancies are interesting because they demand explanations (Birks and Birks, 1980).

4.7.2 MULTIPLE DISCRIMINANT ANALYSIS.

Statistical analyses, including ordination techniques, classification techniques and multiple discriminant analysis may be used to assist in the interpretation of the past floras and by extension, the reconstruction of palaeoenvironments. Fossil pollen data and comprehensive contemporary pollen data are required for multiple discriminant analysis and therefore only the Nuweveldberg and Cederberg data sets were examined using this technique. The results are used to reconstruct patterns of vegetation development and to determine whether modern analogues exist for fossil assemblages. A variety of statistical analyses are available, the relative merits of which are discussed and the reasons for selecting multiple discriminant analysis is given in the following discussion.

Principal components analysis, dissimilarity coefficients and canonical variate analysis have been used to compare and display the affinities of fossil samples (Prentice, 1985; Overpeck *et al.*, 1985; Clark *et al.*, 1986; Birks, 1974, 1976). These techniques are extremely useful, but have certain limitations. One of these limitations is that they do not provide a direct measurement of the "degree of analogy" (Overpeck *et al.*, 1985) and fossil samples with no close modern analogues may be placed spuriously close to some modern samples in the plots of the first few principal components of canonical variates.

Canonical variate analysis assumes that each of the fossil pollen samples originates from one of the vegetation types included in the modern sample. If fossil spectra from other vegetation types are present, they will be positioned in the canonical variate space in which no modern samples are present. This can help with the recognition of fossil samples for which no modern analogue is represented (Birks, 1976). An extension of canonical variate analysis may be used, which provides for the possibility of a discriminant test based on Mahalanobis D^2 between a fossil sample and a set of modern samples.

Multiple discriminant analysis was chosen in preference to principal components analysis, because discrimination and allocation is more explicitly performed by the former. Although principal components analysis permits comparison between fossil and modern pollen spectra in multidimensional space, as shown by Birks and Birks (1980), Birks and Peglar (1980), Birks and Gordon (1985) and Thackeray and Scott (1988), it does not provide a quantitative criterion value to discriminate between groups of samples or intermediate samples. The results may then be influenced by subjective decisions and prevent assigning group membership to new samples of unknown identity (Liu and Lam, 1985). An advantage of principal components analysis is that it allows for samples that fall within ecotones, whereas multiple discriminant analysis works only with *a priori* assemblages from defined communities. The advantage of multiple discriminant analysis is that it can be used in both multivariate discrimination of modern surface samples and the subsequent comparison of fossil and modern assemblages.

Overpeck *et al.* (1985) reviewed the problems of comparing modern and fossil pollen spectra and assessed the usefulness of several dissimilarity coefficients for this purpose. They concluded that all of the dissimilarity coefficients produced congruent results. They suggested that Mahalanobis D^2 distances, measured from canonical variate analysis such

as those provided by discriminant analysis, would be a useful method of determining the degree of analogy between fossil and modern pollen samples (Prentice, 1985; MacDonald and Ritchie, 1986). Direct fossil sample to modern sample measures of distance, such as those examined by Overpeck *et al.* (1985) and Clark *et al.* (1986), are preferable in situations with high heterogeneity among the modern pollen samples from the same vegetation type. Discriminant analysis has been selected in this case, as modern pollen samples do not have a high heterogeneity.

Multiple discriminant analysis compares fossil pollen assemblages from vleis with modern pollen assemblages collected from known vegetation regions (Liu and Lam, 1985). Modern pollen assemblages (ie. modern analogues), which are representative of those shown in the fossil record, are then identified. The application of discriminant analysis to palaeoenvironmental reconstruction for modern and fossil pollen data is constrained by a number of ecological and statistical assumptions. The ecological assumption is that the contemporary pollen samples selected for analysis adequately represent the palynological signature of their parent regions. This depends on the number and spatial distribution of modern pollen spectra used in the analysis in relation to spatial and statistical variability of the pollen rain in these vegetation regions. Given the limited availability of pollen spectra in some of the vegetation regions studied, the spatial distribution of the modern pollen data points are uneven, but were thought to be representative of the area. Analyses and interpretation of the data from the 22 traps in the Nuweveldberg and 16 in the Cederberg confirmed that the data are representative of the surrounding vegetation. Thus the uneven distribution of the modern pollen points should not affect the results.

The assumption, that the same pollen-vegetation relationship exists today as in the past, is necessary for the concept of a modern analogue to hold (Birks and Birks, 1980). Although

difficult to test, this assumption is probably valid for the time scale being considered, viz. the late Pleistocene and Holocene. The term "modern analogue" is used to define a modern pollen spectrum, which matches a fossil pollen sample and is used to interpret the past vegetation (MacDonald and Ritchie, 1986). The statistical assumptions for discriminant analysis are : (1) samples are randomly chosen; (2) probabilities of group membership are equal for all groups; (3) samples are correctly classified; (4) the variance-covariance matrices of groups are statistically equal and (5) the variables are normally distributed within each group. In the present data set, the first assumption is justified. The second assumption may not be completely justified, because there is an unequal number of samples from each of the different zones in the two study areas. Assumption three is justified once the additional "disturbed Mountainveld" assemblage in the Nuweveldberg is included to account for ecotonal areas. The fourth assumption was tested statistically using Bow's M statistic (Nie *et al.*, 1975). Multivariate skewness and kurtosis measures are used to test assumption five (Nie *et al.*, 1975). Unfortunately, measures of skewness and kurtosis could not be calculated for the Upper Karoo group due to the paucity of contemporary pollen samples. Multivariate normality holds for Merxmuellera Mountainveld, Disturbed Mountainveld and Karroid Mountainveld in the Nuweveldberg, and for Restioid Fynbos, Ericaceous Fynbos, Proteoid Fynbos, Undifferentiated Fynbos and "Cedars with an ericaceous understorey" in the Cederberg area. Although the present data set does not meet all the assumptions of discriminant analysis, this is not unusual for ecological data and the technique appears to be relatively robust (Liu and Lam, 1985; MacDonald and Ritchie, 1986).

The BMDP subprogram, DISCRIMINANT, was used to perform the analysis (Jenrich and Sampson, 1983). Discriminant analysis reveals: firstly, whether and to what extent a fossil pollen assemblage has modern analogues based on an index called the

probability of a modern analogue; and secondly, if this modern analogue exists, it relates the fossil pollen assemblage quantitatively to the group of modern pollen spectra representing its modern analogue, based on the probability of group membership.

In discriminant analysis the samples, or in this case taxa, are divided into *a priori* groups and the analysis finds discriminant functions or linear combinations which best characterise the differences between the groups, so that samples of unknown group identity may be assigned to one of the groups. The discriminant functions are also useful for classifying new samples (Hair *et al.*, 1979). The division of samples into *a priori* groups is critical, yet potentially restricting, as it does not allow for samples that fall within the ecotonal areas. The analysis may be explained by plotting each sample as a point in multidimensional space, where each variable represents a dimension. The points are projected onto a plane, which is selected so that the separation between groups is maximised. This plot of variables (function 1 versus function 2) forms part of the canonical variate analysis, which finds linear combinations of the dominant sets of variables in the classification function and permits comparison between modern and fossil spectra. The second set of variables is used to indicate group membership (Jenrich and Sampson, 1983). Discriminant functions are therefore derived to ensure maximum separation between *a priori* groups and to distinguish between pollen assemblages from known vegetation types. Mathematical details of the application of discriminant analysis to palynological data are presented in Appendix G.

In the Nuweveldberg analyses, pollen percentages were calculated based on the sum of 33 taxa. These taxa were taken from those listed on the Bokkraal pollen diagram, including the generic subdivisions, but omitting cryptogram spores, fungal spores, unknowns, unidentifiables and Salicaceae. Salicaceae pollen was excluded as it comes

exclusively from recent plantations and would have little significance in characterising fossil pollen zones. In the analysis, Acocks' (1953) veld types are used as the *a priori* groups, but these vegetation boundaries are not all clearly defined in the Nuweveldberg area and therefore ecotonal vegetation has to be closely examined. In the Central Karoo an additional "disturbed" assemblage is used to account for the diffuse ecotone and disturbed vegetation assemblage between Merxmuellera Mountainveld and the Upper Karroid vegetation. The third statistical assumption made when using discriminant analysis, is sufficiently justified by making the disturbed area a discrete entity and avoiding misplacement.

In the Cederberg, pollen percentages were calculated based on the sum of 36 taxa. These taxa include all those shown on the two pollen diagrams, viz. Driehoek and Sneeuberg pollen diagrams, but omitting spores, unknowns and unidentifiables. The *a priori* vegetation types used were based on the classification system proposed by Campbell (1986a) for the Mountain Fynbos communities. The term "undifferentiated" fynbos is used to describe the arid, Asteraceous fynbos community, which occurs on the eastern margins of the Cederberg.

Multiple discriminant analysis is a useful tool for reconstructing past vegetation changes from pollen stratigraphic evidence and by extension, contributes to the zoning of the pollen diagram. It does however, include some degree of subjectivity as the samples initially have to be classified into *a priori* groups or vegetation types. These are checked and reclassified, if necessary, during the analysis.

4.7.3 TWISA.

However objective, a pollen analyst will tend to divide pollen diagrams into zones not only by considering the changes in the diagram, but by drawing on previous experience and looking for important changes which have been recognised in other pollen diagrams or from other lines of evidence. Because zonation is a form of classification and the data are quantitative and multivariate, numerical methods of classification are often applied to the pollen data to reduce this bias. A variety of methods have been used, including multiple discriminant analysis, principal components analysis and divisive methods (Birks and Birks, 1980), but subjectivity is included as *a priori* groups are required.

TWISA (two-way indicator species analysis) has been used to check the zones obtained from multiple discriminant analysis for the two Cederberg pollen diagrams. This type of hierarchical classification groups similar entities together into classes and arranges the classes into a hierarchy (Gauch, 1982). TWISA is a polythetic divisive classification technique and therefore uses information on all the taxa.

To classify the samples from each core, the two-way indicator species analysis (Hill, 1979a) is used. Random samples were taken from varying depths from the Driehoek and Sneeuberg cores. TWINSPAN produces a classification of samples by the progressive splitting of ordinators at their centres of gravity (Hill,1979a). The program first constructs a classification of the samples, and then uses the classification to obtain a classification of the species according to their ecological preferences. The two classifications are then used together to obtain an ordered two-way table that expresses the species' synecological relations as succinctly as possible. A feature of this technique is that sample sequences are ordered, placing the most similar species together and therefore making

dendrograms clearer. TWINSPAN also constructs a key to the sample classification by identifying several species which are particularly diagnostic of each division in the classification (Hill, 1979a).

4.7.4 ANALYSIS OF VARIANCE (ANOVA).

An analysis of variance is used to test for differences between the means of two or more groups or subpopulations (Hinkle *et al.*, 1985). In a simple one-way analysis of variance each individual, or in this case family, is classified into one category. The equality of means between each pair of groups is then tested by the t-statistic. The BMDP subprogramme, ANOVA-BMDP 1V, was used to perform this simple analysis (Engelman, 1985). In the ANOVA, hypotheses are formulated about the means of the groups on the dependent variable and then tested for statistical significance (Hinkle *et al.*, 1979).

An ANOVA was undertaken to test whether the contemporary pollen data varied significantly from year to year in the Nuweveldberg; and if so, explanations for this variation are sought. The contemporary data from the pollen traps and surface samples taken from 1986 were compared to the contemporary data for 1987. The hypotheses tested were as follows:

H_o: There is no difference in the means of the pollen counts from each zone from 1986 to 1987.

H_a: There is a difference in the means of the pollen counts from each zone from 1986 to 1987.

4.8 CONCLUSION.

The fundamental palynological principles which allow for the reconstruction of former vegetation communities and the problems associated with pollen analysis are outlined. Pollen, often morphologically species-specific, is produced

in varying quantities by all flowering plants, while the more primitive plants produce spores. A primary aim of fossil pollen analysis is to collect uncontaminated samples of the relevant deposit, ensuring that stratigraphic consistency is maintained throughout the sampling process. To this end, sampling is carried out from exposed sections or by using a coring instrument. The process leading to the preparation of slides containing concentrations of pollen is essentially one of sequential sampling and subsampling.

The preparation of a sample suitable for pollen counting from a Holocene deposit involves concentration and is aimed at the disintegration or removal of the non-polleniferous matrix of the sample. The various ways in which this is achieved are based on the small size of the pollen grains and spores, coupled with their extreme resistance to many caustic chemicals. Preparation of the samples is a matter of following a sequence of chemical procedures designed to concentrate the pollen sufficiently for counting and the subsequent statistical procedures (Moore and Webb, 1978; Faegri and Iversen, 1975; Erdtman, 1969). Having obtained a sample of stained pollen suspension, it was counted using absolute counting techniques.

Before identification and counting can be done, a knowledge of the pollen grains is required. A pollen reference collection of slides and photographs, which includes most of the taxa occurring in the study areas was made. At all stages of the investigation, modern analogues were involved. This is particularly important in late Pleistocene and Holocene palaeoecology, where the fossils are closely related to living organisms. Contemporary pollen studies, using pollen traps and surface samples, were necessary to augment the knowledge and understanding of contemporary pollen/vegetation relationships.

The scanning electron microscope forms a valuable tool in palynology. The greater resolution of this microscope

enabled critical identification of similar pollen. In addition, the diagnostic features of the pollen of twelve selected families were examined more closely. A variety of statistical techniques are available to augment interpretation of the data. It is essential that the appropriate method is selected for each problem and data set. Multiple discriminant analysis was a useful tool for reconstructing past vegetation changes from pollen stratigraphic evidence and, by extension, contributed to the zoning of the pollen diagrams. TWISA was also a useful technique which objectively classified the pollen spectrum and checked the pollen zones obtained from the multiple discriminant analysis.

In conclusion, modern studies and more sophisticated techniques have presented a much clearer picture of the pitfalls and problems associated with the identification and interpretation of fossil pollen assemblages than was available to the early workers in this field. Despite this, their basic conclusions have generally been confirmed, which suggests that pollen analysis is a robust and flexible tool which may be used with success to examine the change in vegetation with time.

CHAPTER 5

RESULTS

5.1 INTRODUCTION.

Having obtained a stratigraphic sequence of pollen counts, the next stage in a palynological investigation is to present the results in the form of a diagram prior to the interpretation of the data. Pollen analytical data are invariably complex and are most effectively presented in the form of a pollen diagram (Birks and Gordon, 1985). The pollen diagram forms the central data set for each study area. All of the pollen diagrams have been constructed using the same format, which is adapted from Birks and Birks (1980) and Meadows (1983). To interpret the detailed pollen diagrams, a good understanding of the contemporary pollen spectrum is required, so that relationships between the vegetation of the area, the pollen rain and the contemporary surface sample pollen spectra can be assessed. It is the pollen rain which is deposited on the surface of the vlei and preserved in the organic sediment that eventually contributes to a fossil pollen spectrum and is stratigraphically examined.

In addition to contemporary pollen data, numerical methods of analysis are employed to zone the diagrams and enhance interpretation of the fossil pollen assemblages. Techniques of multivariate analysis have been developed which allow pollen diagrams to be zoned based on mathematical criteria and which provide methods for comparing one pollen diagram to another. It is conventional to divide the pollen diagram into a series of pollen assemblage zones, each of which is considered to have some degree of internal uniformity. In this study, pollen zonation is initially performed subjectively, based on visual similarities or

dissimilarities of pollen frequencies. Multivariate numerical techniques of objective zonation are then used, delimited solely on the basis of mathematical criteria and without reference to inferred climate, vegetation or chronology. The results of the contemporary and fossil pollen investigations and associated statistical manipulations are presented for each of the study areas. The Nuweveldberg and Cederberg areas are examined more intensively than the Winterberg and Sneeuberg Ranges. In the final section of this chapter, the scanning electron micrographs are described, highlighting the diagnostic features of selected taxa.

5.2 THE WINTERBERG RANGE.

5.2.1 FOSSIL POLLEN STUDIES.

i. Stratigraphy and Chronology.

The aim of this investigation was to establish a fossil pollen record which can be used in the reconstruction of past vegetation communities of the Elandsberg section of the Winterberg. Reconstruction of the vegetation communities is limited by the depth to which coring is possible, the age of the sediments and the condition or amount of pollen preserved in the organic deposit. The core from Ellerslie Vlei was shallow, extending to a depth of 160cm. Radiocarbon-dating techniques were employed by the CSIR to date the basal sediments. These sediments are dated at 4 200 BP (Pta-4336) (Appendix H).

The sediment stratigraphy and details of the core from Ellerslie are shown in Figure 5.1. Although this core was black in colour, the mean organic content for the entire core was only 12.7% (Appendix I), which proved to be sufficient for radiocarbon-dating techniques. In the relatively rich organic band at a depth of 80cm, the organic content increased to 13.1% and the number of pollen grains

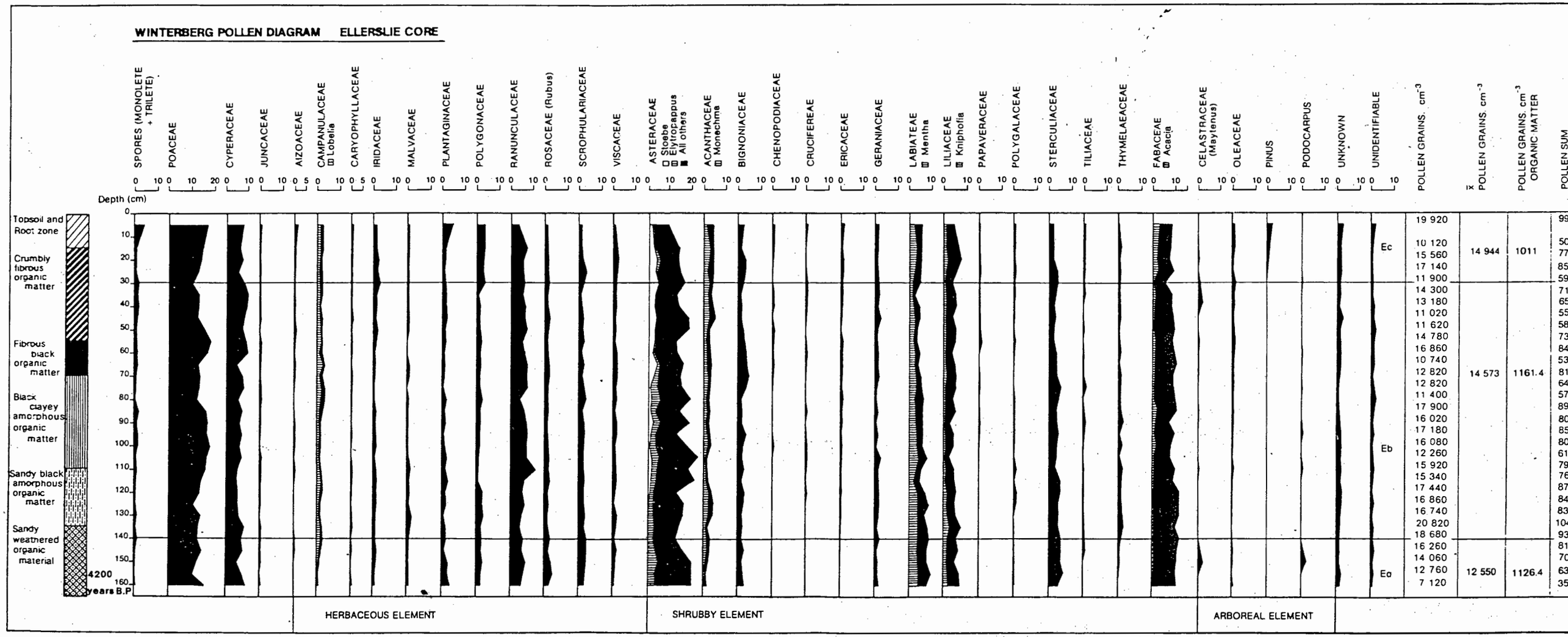

Figure 5.1 Ellerslie pollen diagram from the Winterberg Range.

per volume increased accordingly. The waterlogged root zone (0-20cm), which contained abundant litter and partially decomposed roots, had the highest organic content of 15.5%. Below this the organic matter content decreased progressively to a minimum of 8.8% in the basal samples, where weathered parent material contributes to the sediments. The density of pollen grains per cm^3 decreased substantially at the base of the core.

Absolute counting techniques of pollen frequency determination were adopted. All raw data is tabulated in Appendix J. The pollen sum and the total number of pollen grains per cm^3 are tabulated in Figure 5.1. This density value is a useful measure of the condition of the pollen and the amount of pollen being produced by the prevailing vegetation. The mean pollen density in the organic sediment for each pollen zone shows a substantial increase from the base of the core upwards. If these values are re-calculated and expressed as the mean pollen density per unit weight of organic matter (ie. excluding the sediment), a slightly different pattern emerges: there is a slight **decrease** in the pollen influx from the base of the core upwards.

ii. The Pollen Diagram.

To facilitate interpretation of the pollen diagram, the local vlei vegetation should be distinguished from the regional and extralocal vegetation. In this diagram the taxa are divided into herbaceous, shrubby and arboreal elements. Vlei elements are identified as taxa which occur in the present vlei environment and are known to be hydrophytic. These vlei elements include Cyperaceae, Juncaceae, Ranunculaceae, Labiatae and Liliaceae. Taxa not found in the contemporary pollen trap spectra from the vlei, but found in adjacent upland areas and regional areas, are considered to be representative of the regional environment.

Zonation of the pollen diagram, which is based on a visual classification, proved to be difficult as no obvious changes

were apparent. Three zones are, however, distinguished, although no well defined boundaries are evident. Pollen zones present in the Ellerslie core are described in decreasing chronological order, commencing with the oldest section at the bottom of the core. A brief description of each of the zones is given.

Zone Ea (160-140cm). This zone is characterised by relatively high percentages of Asteraceae, Labiatae, in particular the swamp herb *Mentha aquatica*, Liliaceae, Ranunculaceae and the moisture-indicating Cyperaceae. Labiatae reaches a maximum frequency of 10% and Asteraceae, which is consistently high in the bottom 20cm declines markedly. Lower percentages of Poaceae, Acanthaceae, Campanulaceae and Thymelaeaceae are recorded. A notable feature of this zone is the small, but consistent proportion of pollen from Afromontane forest elements (Celastraceae, Oleaceae, Podocarpaceae) and the corresponding absence of pollen of karroid elements, including *Stoebe, Monechma*, Cruciferae, Chenopodiaceae, Tiliaceae and *Acacias*.

Zone Eb (140-30cm). This zone represents a large proportion of the diagram and a period of many minor fluctuations, against a backdrop of consistently high Poaceae frequencies (average 15%) and lower Cyperaceae values. In the top 30cm of this zone there is an increase in Cyperaceae pollen to 9%, accompanied by a decline in Poaceae frequencies. Celastraceae frequencies also increase slightly in the uppermost layers of zone Eb. A number of taxa appear for the first time or increase markedly in this zone, including *Stoebe*, Aizoaceae, Chenopodiaceae, Cruciferae, Ericaceae, Papaveraceae and Thymelaeaceae. During this period Asteraceae pollen frequencies peak at 20%, along with members of Thymelaeaceae, Polygalaceae and Ranunculaceae. An associated decline in Fabaceae frequencies is recorded at this depth (105-115cm).

Zone Ec (30-0cm). This zone probably represents the last few hundred years of sedimentation and accordingly, shows signs of disturbance. The Afromontane forest elements particularly *Maytenus*, appear to decline to negligible proportions and are replaced by *Acacia* and pines. Shrubby elements, including *Stoebe*, *Monechma*, Bignoniaceae and herbaceous elements including Polygonaceae and Plantaginaceae also increase in this zone. *Pinus* pollen appears for the first time, increasing to a maximum frequency of 5%. The increase in grass pollen corresponds to a decrease in Cyperaceae and Asteraceae pollen in the top 30cm. The arrival of the alien pollen types, particularly *Pinus*, is confined to the top 30cm of sediment which suggests stratigraphic consistency within this core. The recent increase in *Acacia* could be associated with the alien wattle, *A. mearnsii*, which has increased substantially along the east coast in the recent past.

Modern pollen studies were not undertaken during this investigation, but a comprehensive study by Meadows and Meadows (1988) shows the contemporary pollen-vegetation relationships of this area. The contemporary pollen spectra are discussed, along with the implications of these results from Ellerslie pollen diagram in the following chapter.

5.3 THE SNEEUBERG RANGE.

5.3.1 FOSSIL POLLEN STUDIES.

i. Stratigraphy and Chronology.

The sequence of alluvial sediments from the eroded vlei is most interesting and between 30 and 95cm below the surface, an organic soil is evident. The detailed stratigraphic and palynological data are represented in Figure 5.2. The basal material of this organic soil, containing 7.5% of finely divided amorphous organic detritus, rests on a less organic sandy alluvium (5.0%) and grades upwards into a fibrous

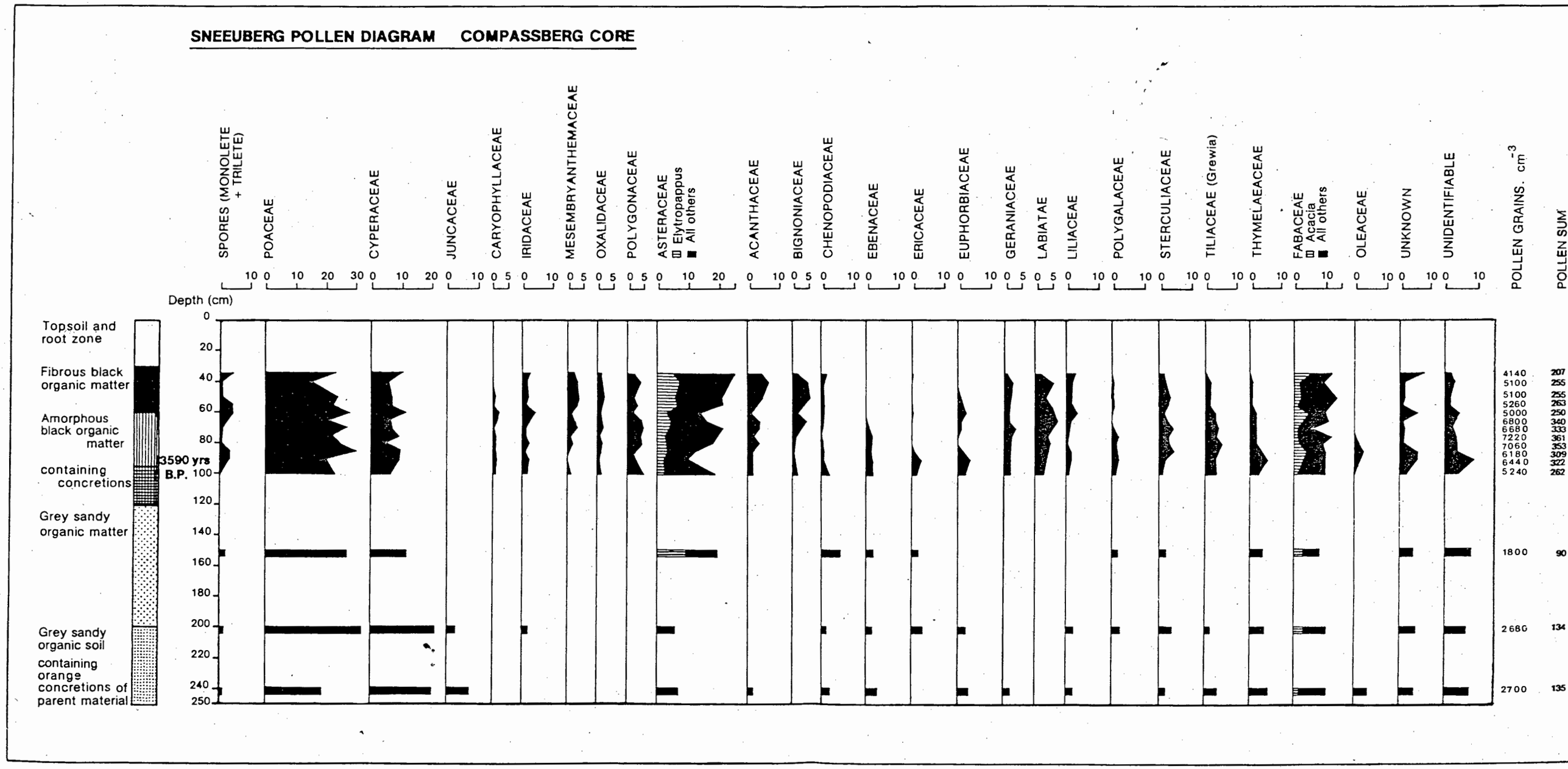

Figure 5.2 Compassberg pollen diagram from the Sneeuberg Range.

carbon-rich horizon which has an organic content of 8.9%. Only three samples were taken from the sandy alluvium below the organic band, while the organic band was sampled every 5cm to give a more continuous pollen spectrum through the palaeosol. The age of the palaeosol is fixed by a radiocarbon date on the basal organic material (90cm) at 3 590 ± 70 BP (Pta-4342).

ii. The Pollen Diagram.

Zoning was not warranted in this pollen diagram, as no distinct zones are apparent in this relatively short sequence. The pollen diagram (Figure 5.2) shows that pollen concentrations are lower in the sandy alluvium, with c.2 500 grains per cm^3 and is dominated by high percentages of both Poaceae and Cyperaceae pollen. Conditions for pollen preservation were not ideal as these alluvial soils are dry and the possibility of differential pollen preservation should not be overlooked. Asteraceae frequencies decline markedly from 20% at 150cm to 8% at a depth of 200cm, while Cyperaceae and Poaceae frequencies increase over the corresponding depths. Poaceae frequencies of 30% are found at 200cm, while Cyperaceae frequencies reach a maximum of 20% at this depth. Arboreal elements are poorly represented in samples below 100cm.

The onset of organic sedimentation at around 3 500 BP is paralleled by a sharp increase in pollen concentrations, to over 7 000 grains per cm^3, at a depth of 80cm below the surface. At the base of the palaeosol, high frequencies of Oleaceae, Ebenaceae and Caryophyllaceae pollen are evident, but these decline sharply towards the surface. Poaceae pollen numbers remain consistently high and, although sedges contribute a consistent proportion of the spectrum, higher percentages of pollen from Asteraceous shrubs, *Elytropappus*, Ericaceae, Chenopodiaceae and Thymelaeaceae are apparent. There is a substantial increase in Mesembryanthemaceae pollen frequencies from the base of the palaeosol upwards. The high contribution of unknown and unidentifiable pollen

grains is probably associated with the poor preservation conditions, particularly below the organic band where pollen is badly corroded. Most of the unidentifiable grains are corroded, which is attributed to oxidation in the aerobic sediments and aridity within the vlei subsequent to deposition. Some interesting changes occur within the period of palaeosol formation, with the shallower horizons (c.30cm) being notable for decreases in grass pollen frequencies and a further increase in the pollen of karroid shrubs, particularly *Elytropappus rhinocerotis*.

5.4 THE NUWEVELDBERG RANGE.

5.4.1 CONTEMPORARY POLLEN STUDIES.

The object of contemporary pollen rain studies is to obtain palynological data which can be used to aid in the interpretation of the fossil pollen diagrams. Before continuing with the palynological investigation, the assumption that the pollen rain spectrum obtained from the pollen traps accurately reflects the prevailing vegetation should be tested. Pollen traps and surface samples have been used to obtain the pollen spectrum for the 1986 season (February 1986 to February 1987) and again for the 1987 season (February 1987 to February 1988) (Appendix J.3 & 4).

i. Pollen Trap Spectra.

Pollen traps were placed in the field on the Nuweveldberg for two consecutive years. Replication proved to be extremely useful, particularly for pollen traps which were vandalised or contaminated during the sampling period. There was a 65% recovery of traps in 1986, which increased to 88% during the 1987 season. An analysis of variance was conducted to assess whether there was a change in the pollen spectrum from the 1986 season (Figure 5.3) to the 1987 season (Figure 5.4) and is reported in section 5.4.iii.

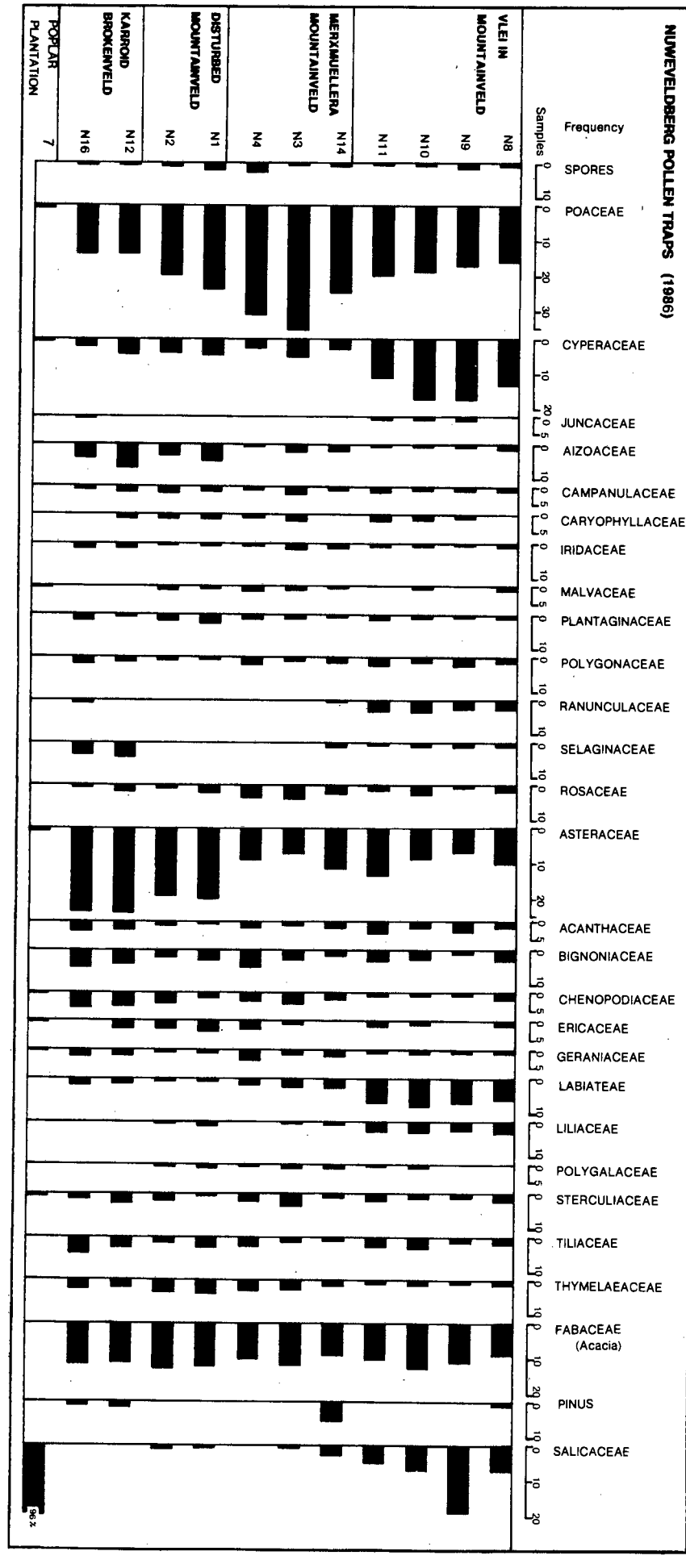

Figure 5.3 Nuweveldberg pollen trap spectra from the 1986 season.

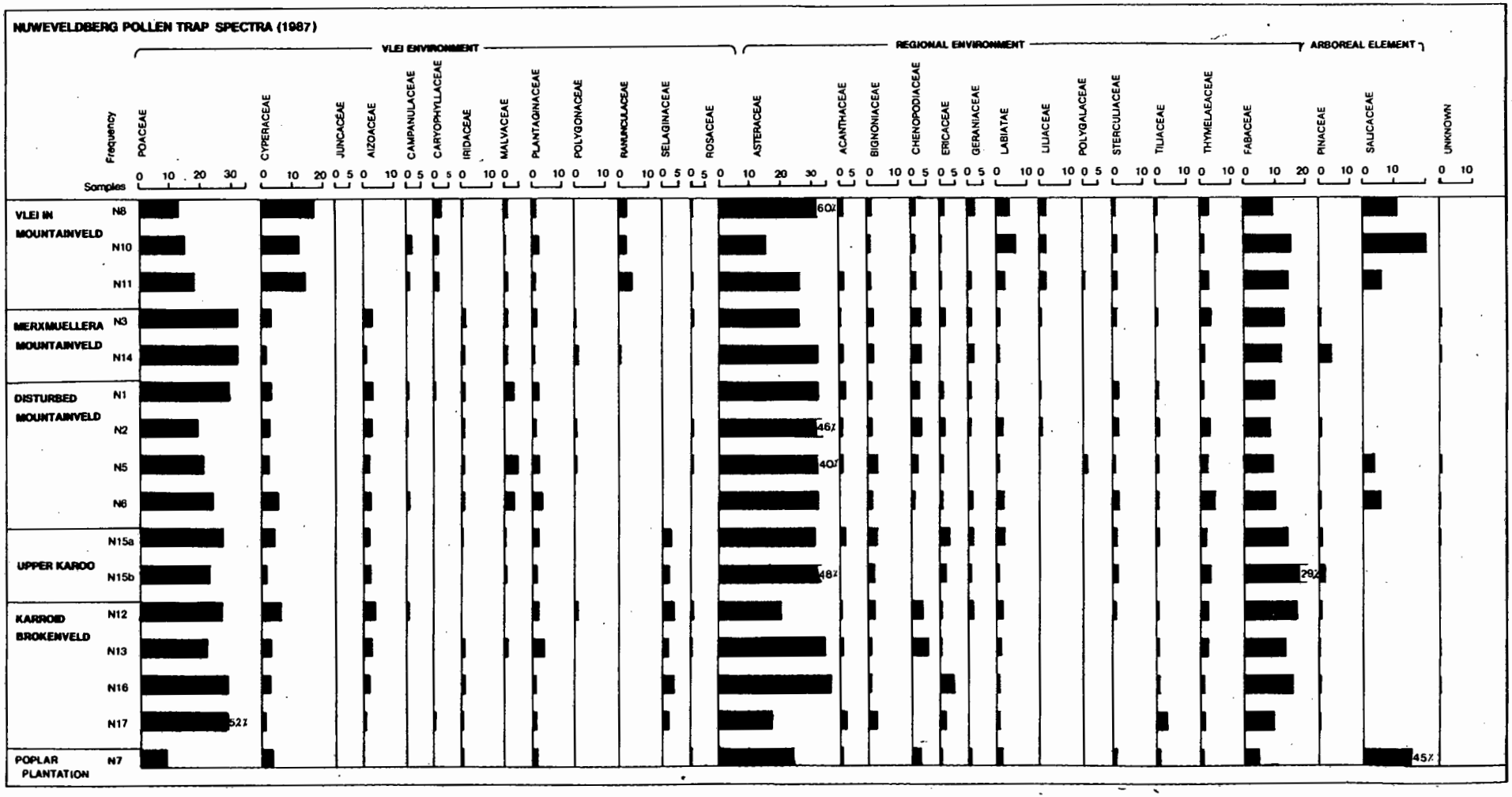

Figure 5.4 Nuweveldberg pollen trap spectra from the 1987 season.

a. Vlei in Merxmuellera Mountainveld (N8, N9, N10, N11). All traps were recovered from the vlei in 1986, whereas traps from the 1987 season were contaminated by bird droppings or in the case of trap N10, all the acetate fibre was removed - presumably by birds or small rodents. Contamination of these traps is accounted for by isolating the "bird droppings" and comparing the pollen spectrum from the contaminated pollen trap with that of the "bird dropping" spectrum.

Poaceae (20% in 1986) and Cyperaceae (15% in 1986) dominate the pollen spectra, with the sedge component being slightly higher in 1987. The contribution by Labiatae, particularly *Mentha aquatica* and the leguminous herbs (12% in 1986 and 15% in 1987) are notable components of the vlei pollen spectra. The asteraceous component is relatively high (10 to 15%) and is associated with the extralocal vegetation. The contribution of pollen from vlei elements is slightly lower in pollen trap N11, as this trap is situated in the peripheral arm of the vlei where the extralocal and regional vegetation has a greater influence. The high contribution of arboreal pollen, in particular Salicaceae, is attributed to the location of the poplar plantation at the outflow area of the vlei. The abundance of Salicaceae pollen is lower at N11, as this trap was located furthest from the plantation. Conversely, it is more abundant at N9 in both 1986 and 1987 as this trap was located closest to the plantation. N10 is situated at ground level below N9, and has notably lower poplar and Asteraceae percentages.

b. Merxmuellera Mountainveld (N3, N4, N14). Poaceae pollen dominates these spectra contributing as much as 35%. The frequency of Asteraceae pollen, which varies from 10% in 1986 to 25% in 1987 and Fabaceae pollen (10%) is representative of the herbaceous elements of these families and the abundance of *Felicia filifolia* within the grasslands. The vegetation consists predominantly of *Merxmuellera disticha, Merxmuellera stricta* and *Themeda*

triandra, interspersed with karroid shrubs and herbs in disturbed and moister areas respectively. The contribution of arboreal taxa in N14 is attributed to the location of this trap near the Mountainview Rest Camp, which is surrounded by introduced trees, including poplars, oaks and pines. The unknowns in N14 are thought to be associated with the arboreal element.

c. Disturbed Mountainveld (N1, N2, N5, N6). These pollen traps have the highest species diversity, with 22 different taxa a single trap. Data were only obtained from N5 and N6 in 1987 as they were vandalised during the 1986 season. The dominant pollen types include Poaceae (25% in 1986; 1987), Asteraceae (25% in 1986; 40% in 1987), particularly *Elytropappus, Stoebe, Euryops* and *Felicia* and the herbaceous elements of Fabaceae, which contributed 12% in both 1986 and 1987. Disturbed Mountainveld is found in patches on the upper plateau and usually associated with areas which have, in the past, been cleared or ploughed by farmers.

d. Upper Karoo (N15a, N15b). Pollen traps N15a and N15b were vandalised during 1986, but the pollen spectrum is available from the 1987 season. This pollen spectrum is dominated by Poaceae (20%), Asteraceae (35%) and Fabaceae (15%) pollen. A number of Karroid bushes, for example *Rhigozum*, Thymelaeaceae and Bignoniaceae contribute to the pollen spectrum: these have not been significant in the other pollen assemblages. This spectrum has a lower species diversity than that of the disturbed Mountainveld. N15b is the pollen trap set at ground level and has a higher percentage of Asteraceae pollen but has lower quantities of all other pollen types.

e. Karroid Brokenveld (N12, N13, N16, N17). Despite being located in a National Park, the recovery of these traps was low in 1986 due to vandalism as these traps were conspicuous in the sparse vegetation and, in addition, were located in close proximity to the main access road in the Park. These

pollen spectra are dominated by Poaceae (15% in 1986; 22% in 1987), Asteraceae (25% in 1986; 35% in 1987) and Fabaceae (13% in 1986; 12% in 1987). Asteraceae pollen is dominant in the Karroid Brokenveld.

The reasonably high contribution of Fabaceae pollen is attributed to *Acacia* spp which are common on the Karoo plains. These are, however, under-represented, as *Acacia* flowers are entomophilous and the polyad pollen grains are large and not buoyant. Chenopodiaceae pollen (7%) is, for the first time, well represented and such shrubs are common on the Karoo plains. The contribution by a variety of small shrubs, for example Acanthaceae, Bignoniaceae (8% in 1986; 3% in 1987), Tiliaceae (6% in 1986; 4% in 1987) and Thymelaeaceae, should be noted. Although they do not occur in high pollen frequencies, these "karoo-bushes" and shrubs are widely distributed and constitute an important component of the vegetation. The occurrence of Pinaceae pollen in N12 (1986) and N13 (1987) is attributed to the cluster of pine trees located approximately 1.5km from the pollen traps.

ii. Surface Sample Spectra.

Surface samples were taken from the base of each of the pollen traps. The pollen in these samples is corroded and damaged which is attributed to the poor preservation conditions in the dry surface soils. Sampling should be done with great care to avoid biases related to over-representation of adjacent or surrounding plants. The surface sample spectra are represented in Figures 5.5 and 5.6.

a. Vlei in Mountainveld (Ns8, Ns10, Ns11). The dominant pollen taxa include Poaceae (20%), Cyperaceae (10% in 1986; 20% in 1987), Labiatae, Fabaceae, (particularly in 1986) and Salicaceae in 1987. Labiatae, which is represented by *Mentha aquatica*, is particularly abundant in 1986 (7% in Ns8, 15% in Ns10, 10% in Ns11) but less significant in the 1987 spectrum; whereas Cyperaceae pollen is more abundant in

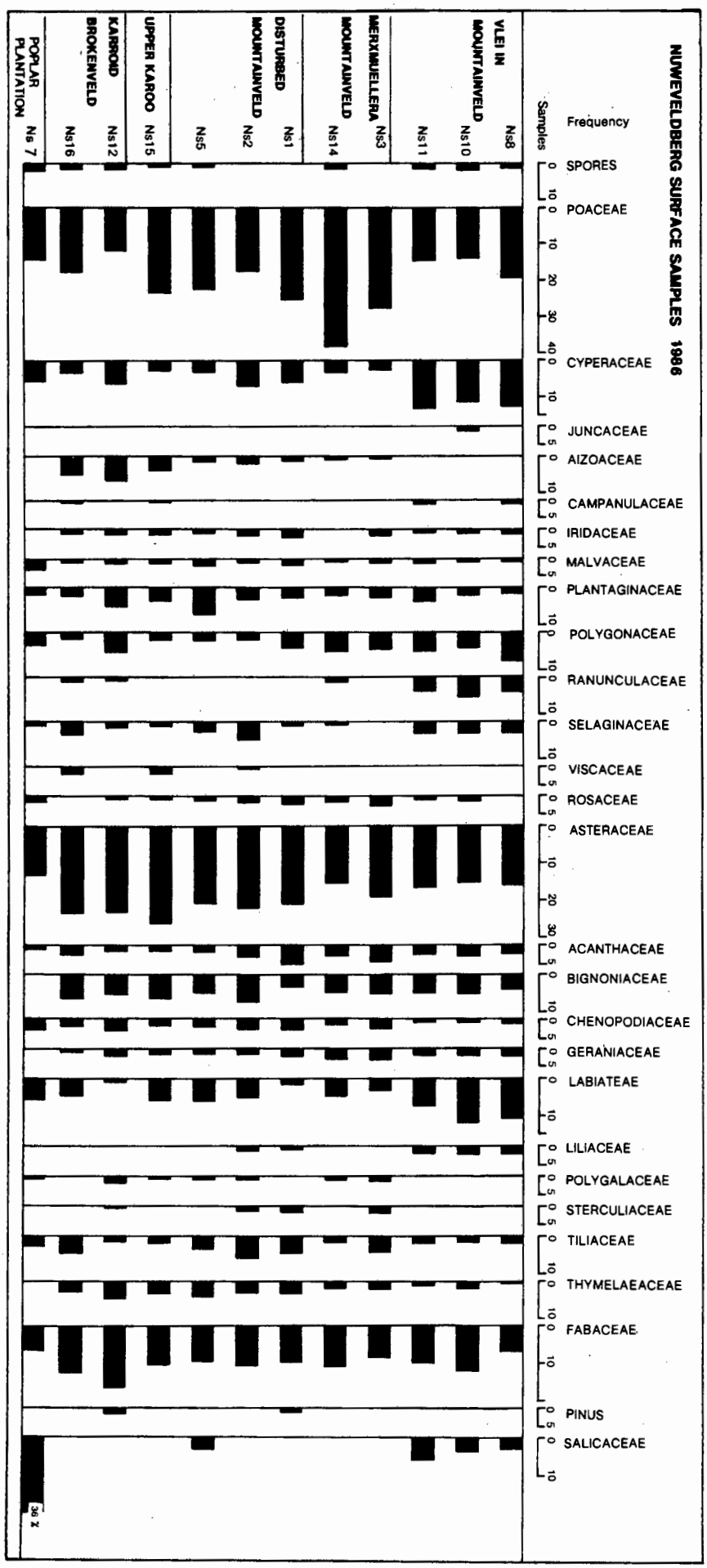

Figure 5.5 Nuweveldberg surface sample spectra from the 1986 season.

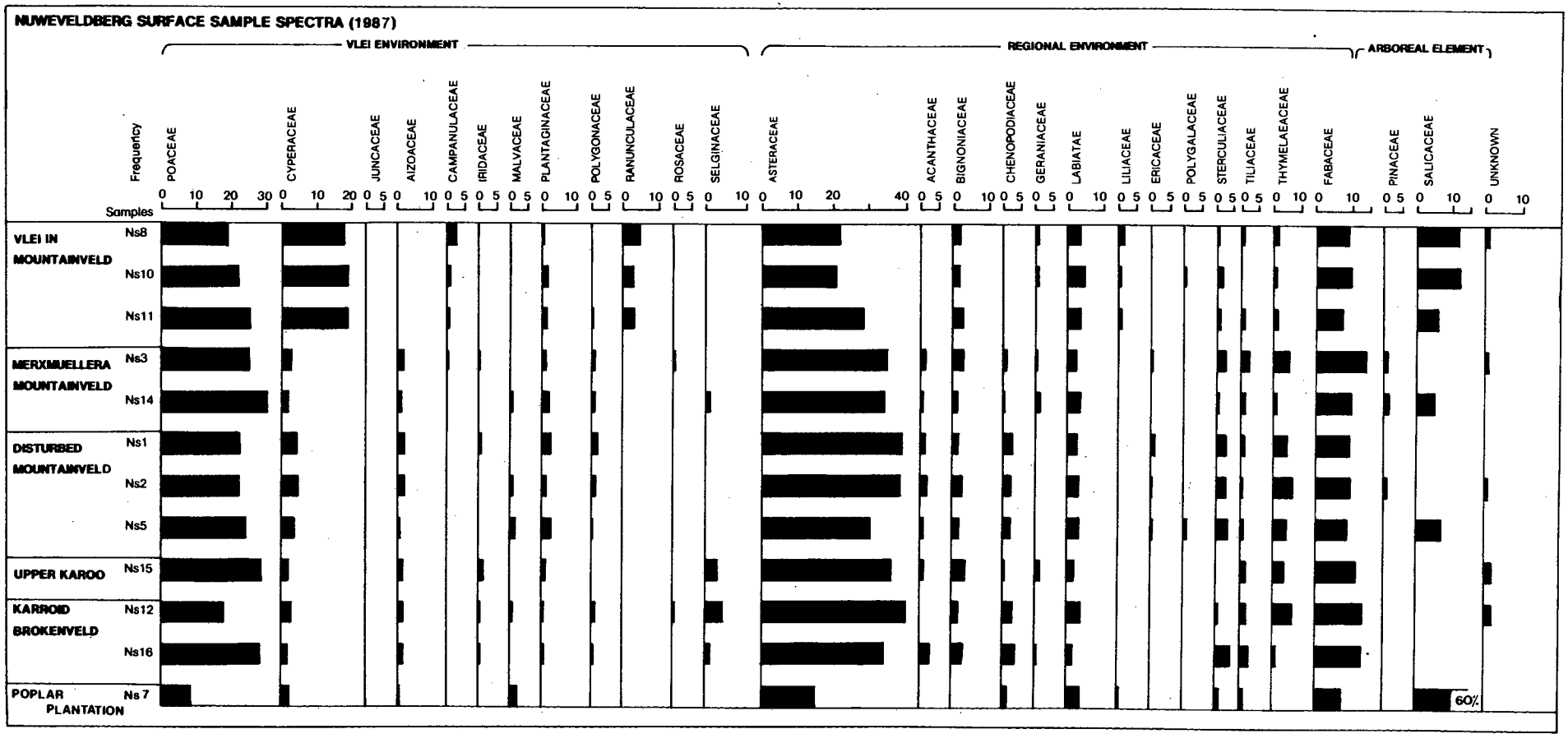

Figure 5.6 Nuweveldberg surface sample spectra from the 1987 season.

1987 (20%) as compared to 1986 (12%). Salicaceae is abundant in the pollen trap spectra and is associated with the poplar plantation adjacent to the vlei. In the 1987 spectrum, the abundance of poplar pollen decreases with distance from the plantation ie. sample Ns8 is closest to the plantation and Ns11 is furthest away. This trend is not as apparent in the 1986 pollen spectrum.

b. Merxmuellera Mountainveld (Ns3, Ns14). The pollen spectra from this assemblage are similar to those obtained from the disturbed Mountainveld, particularly Ns3 which was adjacent to a disturbed area. The percentage of Poaceae pollen is lower than anticipated for this vegetation type where the dominant plant is *Merxmuellera.* When comparing the spectra from all vegetation assemblages it is apparent that Poaceae percentages are highest for the spectra from within Merxmuellera Mountainveld.

The contribution by Asteraceae pollen is notably higher during the 1987 season (18% in 1986; 30% in 1987), indicating the possibility of an increase in pollen production from Asteraceous shrubs in the grasslands. The prevalence of arboreal elements (6% in 1987) within Ns14 is attributed to the proximity of the sampling point to Mountainview Rest Camp, where numerous introduced trees are found.

c. Disturbed Mountainveld (Ns1, Ns2, Ns5). These pollen spectra are dominated by Asteraceae (20% in 1986; 35% in 1987), with notable contributions by Poaceae (20% in 1986; 22% in 1987) and Fabaceae (10% in 1986 and 1987). The frequency of pollen from Karroid and Macchia-type shrubs is greatest in this vegetation assemblage. These shrubs include Acanthaceae, Bignoniaceae (8% in 1987), Tiliaceae, Polygonaceae and Thymelaeaceae.

d. Upper Karoo (Ns15). This pollen spectrum is similar to that of the disturbed Mountainveld assemblage, but has fewer

vlei elements. The succulent elements (Aizoaceae) contribute a notable proportion (4%). The dominant pollen types are Asteraceae (30% in 1986; 35% in 1987), Poaceae (22% in 1986; 28% in 1987) and Fabaceae (12% in 1986 and 1987). Although the Poaceae frequencies are similar to disturbed Mountainveld, the type of grass is slightly different; this distinction is not apparent in the pollen spectrum as it is not possible to differentiate Poaceae pollen into generic categories. The Upper Karoo vegetation is limited to the middle plateau which has infertile rocky soils and is covered with shrubs and grasses of the "white" type.

e. *Karroid Brokenveld (Ns12, Ns16).* Within the pollen spectrum, the "Karoo-bushes" are represented by Asteraceae (20% in 1986; 40% in 1987), Bignoniaceae (8% in 1986; 3% in 1987), Chenopodiaceae, Tiliaceae and Thymelaeaceae. Fabaceae frequencies are high (20% in 1986 and 14% in 1987), with *Acacia* pollen contributing markedly to this value.

iii. Analysis of Variance.

a. *Pollen Trap Data.* An analysis of variance was undertaken to examine whether pollen trap spectra collected during the 1986 season vary significantly from those collected during the 1987 season. Results of this analysis are tabulated in Appendix K. A significant ($p<0.05$) difference was found in 23% of the taxa over the one year period (1986 to 1987). The taxa were Iridaceae, Asteraceae, Tiliaceae, Acanthaceae, Bignoniaceae, Rosaceae and Polygonaceae. No significant difference was shown for the remaining 77% of the taxa.

b. *Surface Samples.* An analysis of variance was also undertaken to examine whether the pollen spectra obtained from the surface samples during the 1986 season vary significantly from those obtained during the 1987 season. A significant difference was found in 43% of the taxa from 1986 to 1987 (Appendix K). The taxa were Labiatae,

Asteraceae, Ericaceae, Plantaginaceae, Tiliaceae, Rosaceae, Acanthaceae, Bignoniaceae, Geraniaceae, Sterculiaceae, Polygonaceae, Polygalaceae and Selaginaceae. It appears that it is mainly the "Macchia-type" pollen, which may be produced by plants influenced by aridity, that vary. The families which show significant variation in both the pollen trap and surface sample spectra from 1986 to 1987 include Acanthaceae, Asteraceae, Bignoniaceae, Polygalaceae, Polygonaceae, Rosaceae and Tiliaceae.

5.4.2 FOSSIL POLLEN STUDIES.

i. Stratigraphy and Chronology.

Two cores were extracted from Bokkraal Vlei. Core 1 and Core 2 were taken 1.5m from each other, in the deepest part of the vlei. The 120cm core (Core 1, Figure 5.7) and the 90cm core (Core 2, Figure 5.8) were palynologically examined and compared. At the base of each of the cores was the grey-brown parent material which forms the underlying bedrock. This partially weathered bedrock forms the base of the vlei and the overlying organic matter indicates the onset of sedimentation in this area. A radiocarbon-dated basal sample yielded an age of 760 $\pm$ 50 BP (Pta-4351).

The accumulation of sediment on the Nuweveldberg has been relatively simple during this period and other than the onset of organic deposition some 760 years ago, there appear to be no signs of marked geomorphological and hydrological changes within the sedimentary record. The stratigraphy of the two cores is similar, showing no unconformities or mixing of sediments. These sediments have a mean organic content of 13.1% (Appendix I), which is sufficient for radiocarbon-dating. The organic matter content decreases from 15.1% in the top 20cm to 10.6% at the base of the core.

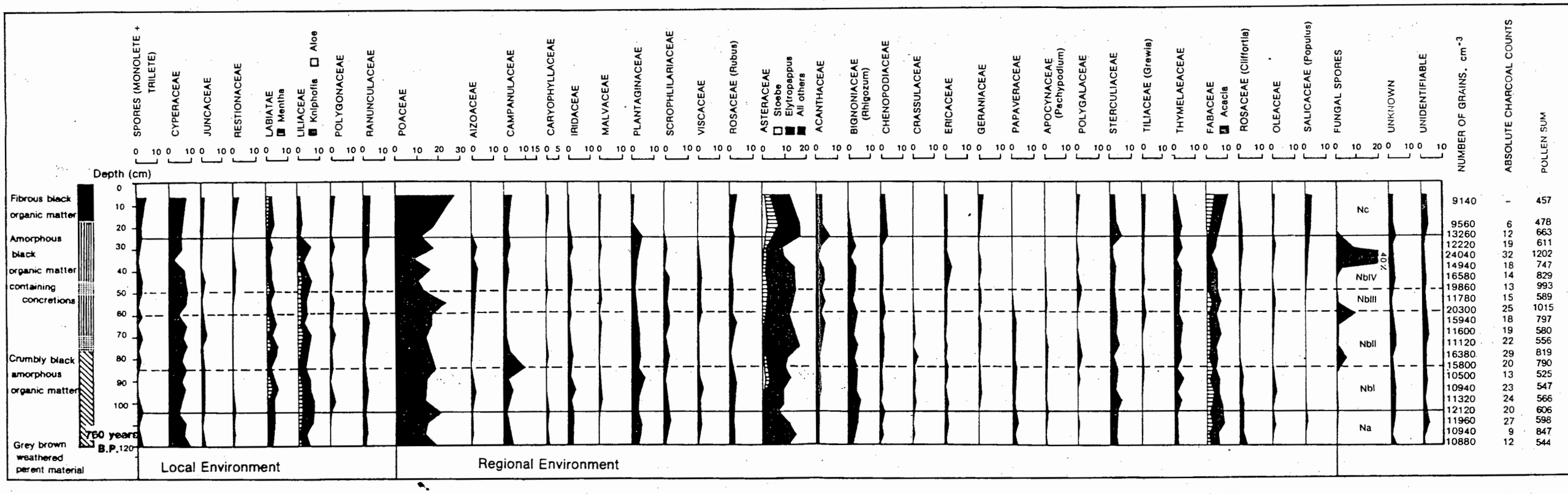

Figure 5.7 Bokkraal Core 1 pollen diagram from the Nuweveldberg.

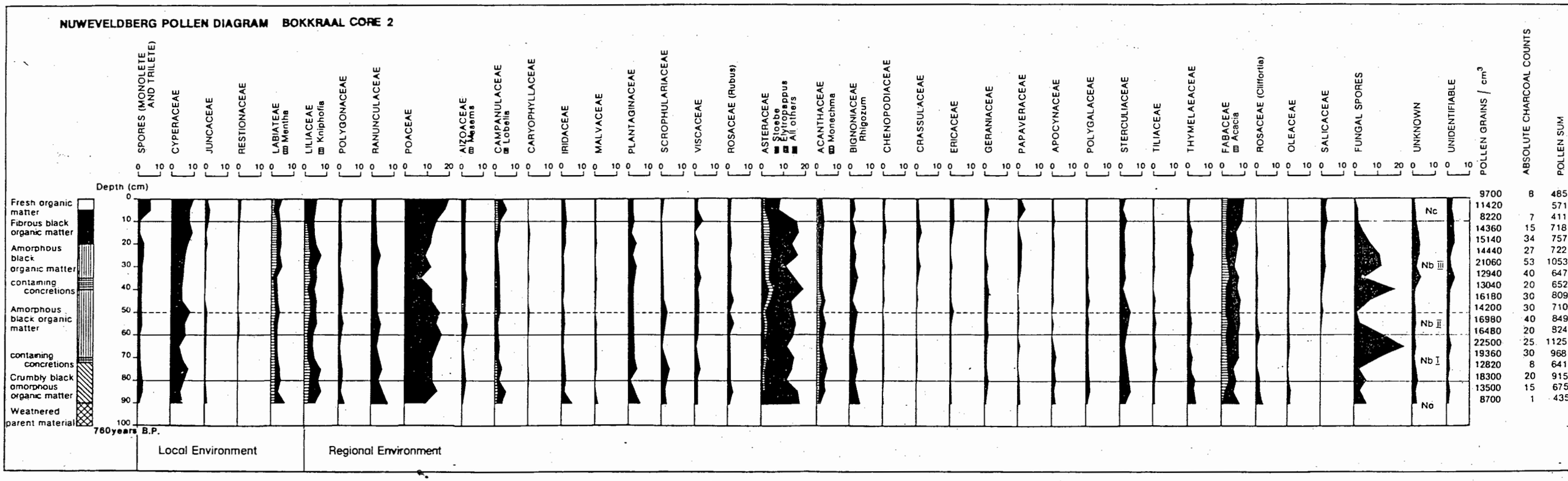

Figure 5.8 Bokkraal Core 2 pollen diagram from the Nuweveldberg.

DRIEHOEK VLEI POLLEN DIAGRAM

SPORES Monolete / Trilete
POACEAE
CYPERACEAE
RESTIONACEAE
AMARYLLIDACEAE
FUMARIACEAE
JUNCACEAE
LABIATAE
LILIACEAE
OXALIDACEAE
RANUNCULACEAE
AIZOACEAE
APIACEAE
ASTERACEAE Stoebe-type / Others
BRUNIACEAE
CAMPANULACEAE
CARYOPHYLLACEAE
CRUCIFEREAE
ERICACEAE
FABACEAE
GERANIACEAE
IRIDACEAE
MALVACEAE
PROTEACEAE
POLYGALACEAE
ROSACEAE (Cliffortia)
RHAMNACEAE
RUBIACEAE
RUTACEAE
SANTALACEAE
SCROPHULARIACEAE
SELAGINACEAE
STERCULIACEAE
THYMELAEACEAE
MYRICACEAE
PINACEAE
CUPRESSACEAE
UNKNOWN
UNIDENTIFIABLE Crumpled / Broken
POLLEN GRAINS cm^{-3} x 100
POLLEN SUM

STRATIGRAPHY

Depth (cm.)

- Root zone
- Sandy black fibrous organic matter
- Sandy black amorphous organic matter
- with finer sand
- Finer sandy brown amorphous organic matter
- containing oxidised concretions
- Sandy black amorphous organic matter — 3230 yrs. B.P.
- Wet amorphous layer
- Sandy brown amorphous organic matter
- becoming black
- with coarse sand particles
- oxidised lens
- Fine black amorphous organic matter
- Sandy black amorphous organic matter — 0090 yrs B.P.
- with lens of coarse sand
- Fine black amorphous organic matter — 14600 yrs B.P.

Df
DeIV
DeIII
DeII
De
Dd
DcIII
DcII
DcI
Db
Da

LOCAL ENVIRONMENT
REGIONAL ENVIRONMENT

ii. The Pollen Diagram.

To facilitate interpretation, the local vlei vegetation is separated from the regional and extralocal vegetation. The fossil pollen extracted from the dry organic sediments from the Karoo were remarkably well preserved, with minimal corrosion or damage to the grains. Taxa representative of the local environment are extrapolated from the pollen trap spectra (Figure 5.3) and surface sample spectra (Figure 5.5). Taxa occurring in the present vlei environment and known to be hydrophytic are assumed to be representative of the local environment. These taxa are usually over-represented in the fossil pollen spectra. Taxa not found in the vlei spectra, but present in pollen trap and surface sample spectra from adjacent areas and regional areas are representative of the regional environment. Preliminary vegetation mapping of the present vlei environment was undertaken to augment the contemporary pollen data and facilitate the differentiation of vlei and regional taxa. The distinction between vlei and regional taxa may, however, be problematic if no contemporary pollen data and vegetation mapping is undertaken. Throughout this discussion the term regional vegetation is used to represent both regional and extralocal vegetation. Zonation of the pollen diagram is initially based on visual classification and then checked using numerical techniques. Three zones are distinguished in Core 1 and Core 2, although no sharply defined boundaries are evident.

Zone Na (118-105cm in Core 1; 90-80cm in Core 2). The bases of Bokkraal Core 1 and 2 are characterised by high pollen percentages of Asteraceae (16%), Caryophyllaceae (2% in core 1), Rosaceae, particularly *Cliffortia* (3% in core 2) and the herbaceous taxa of Fabaceae. The frequencies of Poaceae, Iridaceae and Sterculiaceae pollen are higher than those of zone Nb. There are high frequencies of the local vlei elements, for example Cyperaceae (core 1), Campanulaceae, Labiatae and Liliaceae.

Zone Nb (105-25cm in Core 1; 80-10cm in Core 2). This zone represents a large section of the pollen diagrams and a period of many minor fluctuations. The fluctuations of the taxa from the regional environment should be seen against a backdrop of relatively consistent frequencies of vlei elements, ie. Cyperaceae, Campanulaceae, Polygonaceae, Labiatae pollen. For the major portion of this zone, the percentages of Asteraceae (15%), Aizoaceae, Bignoniaceae and Thymelaeaceae pollen are well represented, whereas percentages of Poaceae, Caryophyllaceae (core 1) and *Cliffortia* pollen have decreased in relation to zone Na. In sub-zones Nb111 (Core 1) and Nb11 (Core 2), there is a peak in percentages of Poaceae (25%) and a slight increase in Caryophyllaceae frequencies. Salicaceae pollen appears for the first time.

Zone Nc (25-0cm in Core 1; 10-0cm in Core 2). In the uppermost zone of both diagrams, changes in frequency include increases in Poaceae (about 30% in core 1), Geraniaceae, Ericaceae, Fabaceae (10%), particularly *Acacia*, and Salicaceae pollen. These increases are associated with an increase in the proportion of *Elytropappus* pollen in core 1, but a decreasing total frequency of Asteraceous pollen. There is an associated decrease, particularly in core 1 in Bignoniaceae, Aizoaceae, Iridaceae and Thymelaeaceae pollen.

Charcoal numbers, estimated from the absolute number of charcoal particles per slide, yield some information about the possible frequency of veld fires in this area. The pollen densities have no direct correlation with the charcoal fragment frequencies: core 1, r=0.019; core 2, r=0.018 (Figure 5.7). However, a lagged relationship may exist between the charcoal and the total number of pollen grains per volume viz. at depths of 35cm in core 1 and 30cm in core 2.

5.4.3 MULTIPLE DISCRIMINANT ANALYSIS.

i. Contemporary Vegetation-Pollen Relationships.

Discriminant functions are derived which classify all contemporary pollen samples from known vegetation regions on the Nuweveldberg into one of the five *a priori* assemblages viz. Merxmuellera Mountainveld, disturbed Mountainveld, Upper Karoo, Karroid Brokenveld and the vlei environment.

The variance within the modern pollen data is accounted for by three discriminant functions in the case of the surface sample spectra and by one discriminant function in the case of the pollen trap spectra. The discriminant functions of the former spectra accounted for 99.5%, 0.49% and 0.01% of the total variance. This shows that the discriminating power of the first two functions is high, although the first four functions are used by the BMDP programme. A comparison of the objectively predicted group membership and the *a priori* group membership shows that 100% of pollen trap samples are correctly classified and 82% of the surface sample spectra are correctly classified. The close agreement between the two methods of classification (subjective/*a priori*) indicates that the modern pollen spectra, particularly those of the pollen traps, are reliable contemporary data bases which may be used to determine analogue palaeovegetation assemblages.

The discriminant or canonical scores for the eleven pollen traps and surface samples are plotted against the first two discriminant functions on the ordination plots in Figures 5.9 and 5.10. The pollen trap scores show that the group centroids are clearly separated from each other and the samples have little variation about their mean. Figure 5.9 shows that the vegetation communities may be separated into distinct vegetation assemblages on the basis of their pollen rain characteristics. This analysis was conducted using the 1986 pollen trap spectrum, which does not have a sample from the Upper Karoo assemblage. The surface sample spectra are plotted in the same way as the pollen trap samples but are

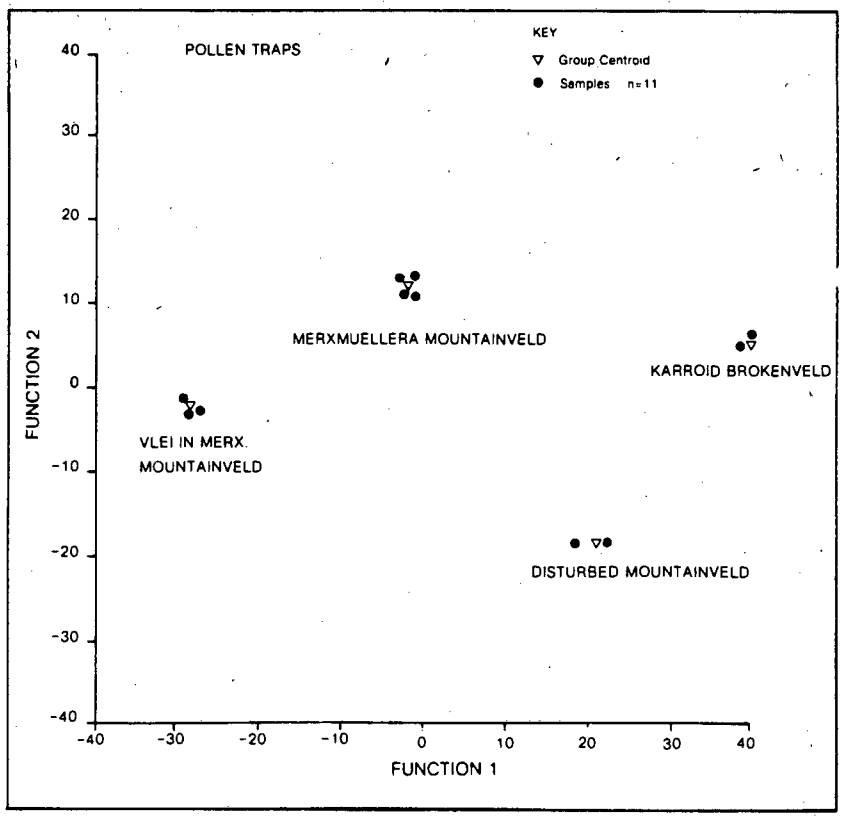

Figure 5.9 An ordination plot of the Nuweveldberg pollen trap samples along discriminant functions 1 and 2.

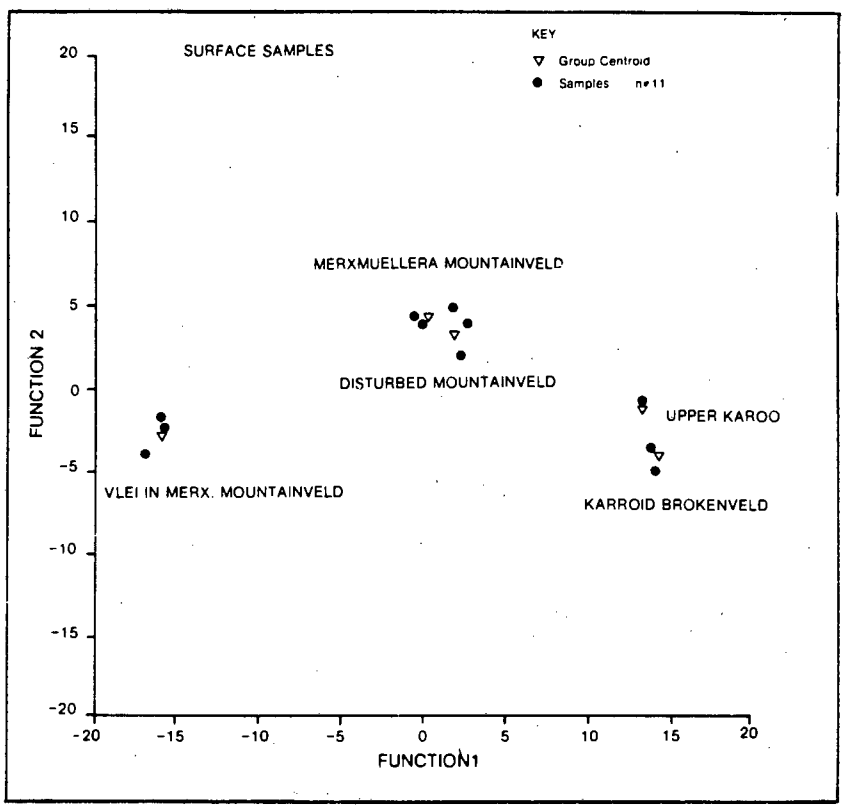

Figure 5.10 An ordination plot of the surface samples along discriminant functions 1 and 2. Pollen data from the Upper Karoo is omitted from the data set.

slightly less defined. The centroids of Merxmuellera Mountainveld and disturbed Mountainveld are close to one another, as are those for the Upper Karoo and Karroid Brokenveld. This indicates that the disturbed Mountainveld vegetation has affinities with Merxmuellera Mountainveld. Similarly, affinities are apparent between Karroid Brokenveld and the Upper Karroid vegetation. Replication of surface sample data or a larger data set would improve the definition of each assemblage.

a. *Vegetation Zonal Index.* The probabilities of group membership in the predicted and second most probable groups of variables, ie. functions 1 and 2 are calculated for each contemporary pollen sample. In all cases, the second most probable group is the vegetation assemblage that is geographically adjacent to the predicted assemblage. These probabilities reflect the zonal pattern of the vegetation along a gradient. Therefore, it is possible to convert the probabilities of these first two groups (functions 1 and 2) into a single "vegetation zonal index" for each sample. Contemporary pollen spectra typical of a vegetation region (100% probability of group membership) are assigned specific zonal indices, corresponding with the vegetation assemblages along the gradient ie. Vlei in the Mountainveld, Merxmuellera Mountainveld, disturbed Mountainveld, Upper Karoo and Karroid Brokenveld are assigned indices of 1.0, 2.0, 3.0, 4.0 and 5.0 respectively. Samples classified as transitional between two vegetation assemblages are then assigned intermediate zonal indices relative to the two probabilities of group membership. For example, a sample classified as 90% Upper Karoo (ie. the predicted group) and 10% Karroid Brokenveld, would have a zonal index of 4.1. The vegetation zonal indices for surface and pollen trap data all approximate 100%, as the samples are from known vegetation assemblages and ecotonal areas are accounted for by the "disturbed Mountainveld" assemblage. The zonal indices for the pollen trap spectra are well defined with no intermediate indices (Figure 5.11), whereas the surface

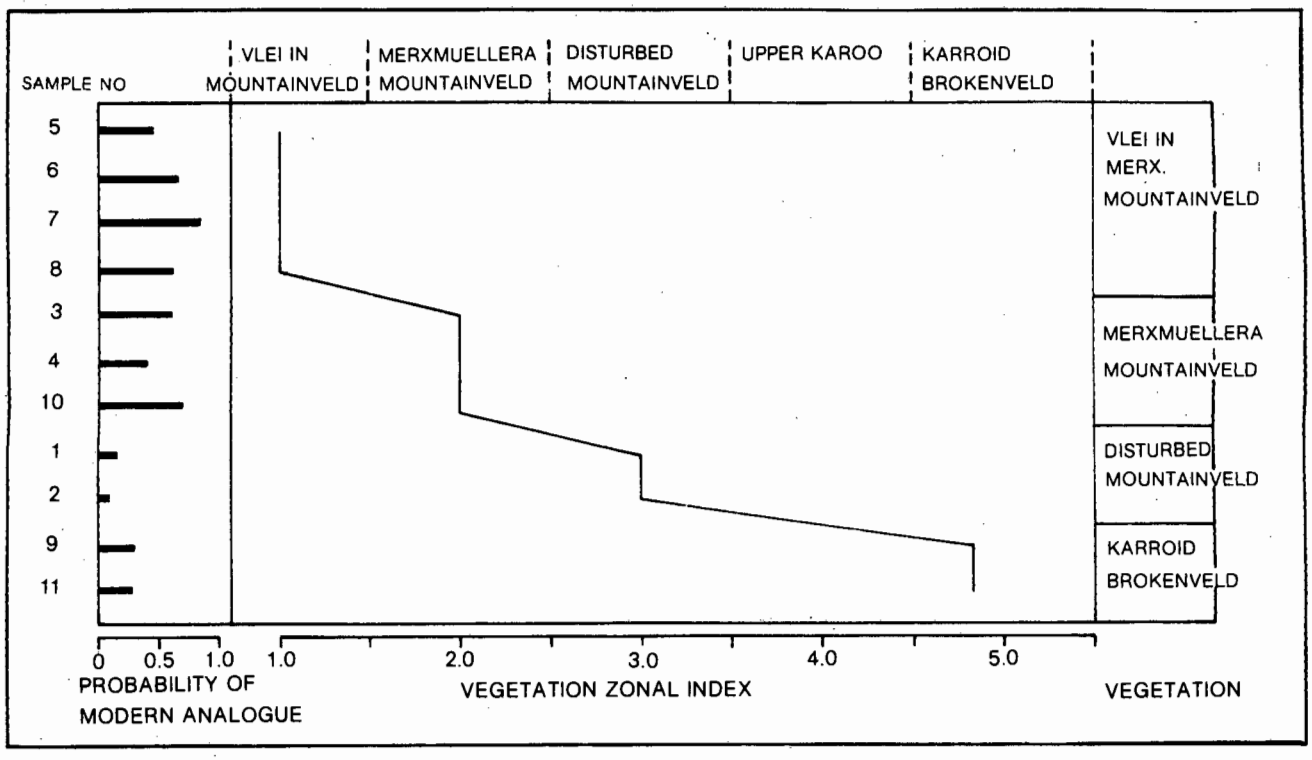

Figure 5.11 Results of discriminant analysis for the pollen traps located in different vegetation assemblages.

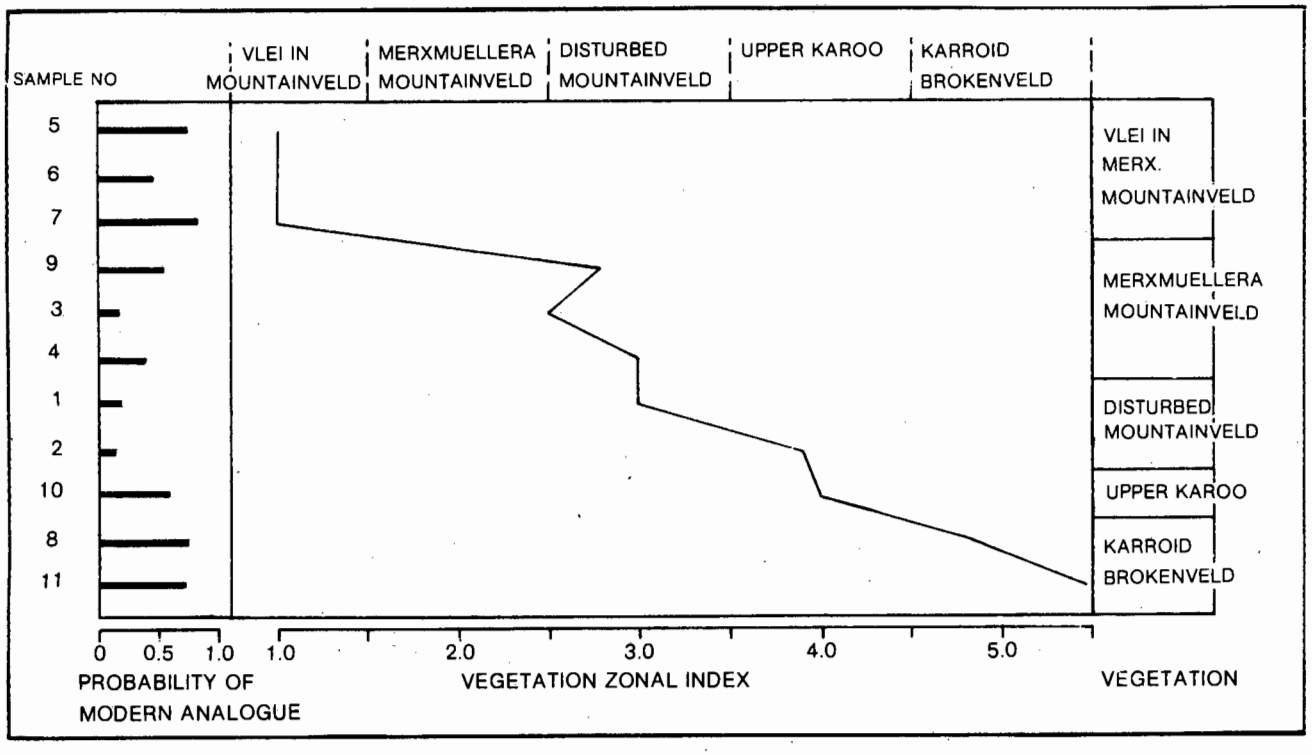

Figure 5.12 Results of discriminant analysis for the surface sample spectra from the different vegetation assemblages on the Nuweveldberg.

sample spectra have less distinct canonical scores and have two intermediate zonal indices within the disturbed Mountainveld and Upper Karoo categories, as shown in Figure 5.12.

b. Probability of a Modern Analogue. This index indicates the probability that samples from the modern pollen group, to which a fossil pollen sample is assigned, will be positioned in the vicinity of the fossil sample on the canonical variate axes. In palynological terms, it compares a pollen assemblage with the "palynological signature" of its assigned vegetation region, as represented by the group centroid. The probability of a modern analogue is relatively high (ie. 0.5-1.0) for the majority of the pollen trap samples (Figure 5.11), whereas lower probabilities of between 0.0 and 0.5 are found in disturbed areas, because the component taxa vary greatly from one disturbed area to another. The probability of modern analogues are higher for surface samples (Figure 5.12). Modern analogue probabilities are low for disturbed Mountainveld.

ii. Fossil Pollen Samples.

The probability of a modern analogue and the vegetation zonal indices are calculated for each fossil pollen spectrum in the same way as for contemporary data. These values are then plotted stratigraphically for the pollen sequence of Bokkraal Vlei.

a. Vegetation Zonal Indices. These indices are plotted for fossil samples in Figure 5.13 and show relatively large changes in vegetation from one zone to the next, which are not represented in the pollen diagram. These changes are due to the linear scale on which the vegetation types are plotted, but would be better represented on a three-dimensional plot. The zonal index is high for Karroid Brokenveld and Upper Karoo, approximating 3.1 (90%) and 2.0 (100%) respectively. The index is lower for Merxmuellera Mountainveld, at 1.5 (50%) which indicates an intermediate

value between Merxmuellera Mountainveld and the Upper Karroid zone. This zone corresponds with the disturbed Mountainveld in Zone Nc. The sharpness of resolution of zone Nc is due to the good discriminators, which are characteristic of specific communities and the absence of the "disturbed Mountainveld" category in the lower part of the core (zones Na and Nb).

b. Probability of a Modern Analogue. Palaeovegetation types, inferred from fossil pollen assemblages without modern analogues, are detected by computing the probability of a modern analogue, thus helping to elucidate vegetation assemblages. Vegetation zonal indices indicate that the initial vegetation (palaeovegetation) prevailing about 760 years ago was Upper Karoo followed by Merxmuellera Mountainveld, returning to Upper Karoo and then Karroid Brokenveld occurred in zones Nb(IV) and Nc. Irregularities are found in Zone Nc, where the *a priori* palaeovegetation is Merxmuellera Mountainveld (zonal index of 1.0) and the predicted value is 1.5, indicative of an intermediate, ecotonal vegetation type (Figure 5.13). The probability of a modern analogue is low (0.5) for samples of this zone, indicating that although Merxmuellera Mountainveld is predicted to have prevailed during this period, it does not have a modern analogue. When further investigated, using "disturbed Mountainveld" as an *a priori* assemblage, the modern analogue is found to correspond with this vegetation assemblage. Although Merxmuellera Mountainveld appears to be well-defined in Figure 5.14, the vegetation zonal indices in Figure 5.13 indicate an intermediate or disturbed Merxmuellera Mountainveld (index of 1.5) in zone Nc. In order to substantiate the idea that pollen assemblages in the top 25cm (zone Nc) represent vegetation assemblages without a modern analogue, the discriminant scores for the fossil pollen spectra are plotted along the first two discriminant functions (Figure 5.14) and compared to the surface samples. The pollen zone Nc, representing Merxmuellera Mountainveld, lies outside the range of the

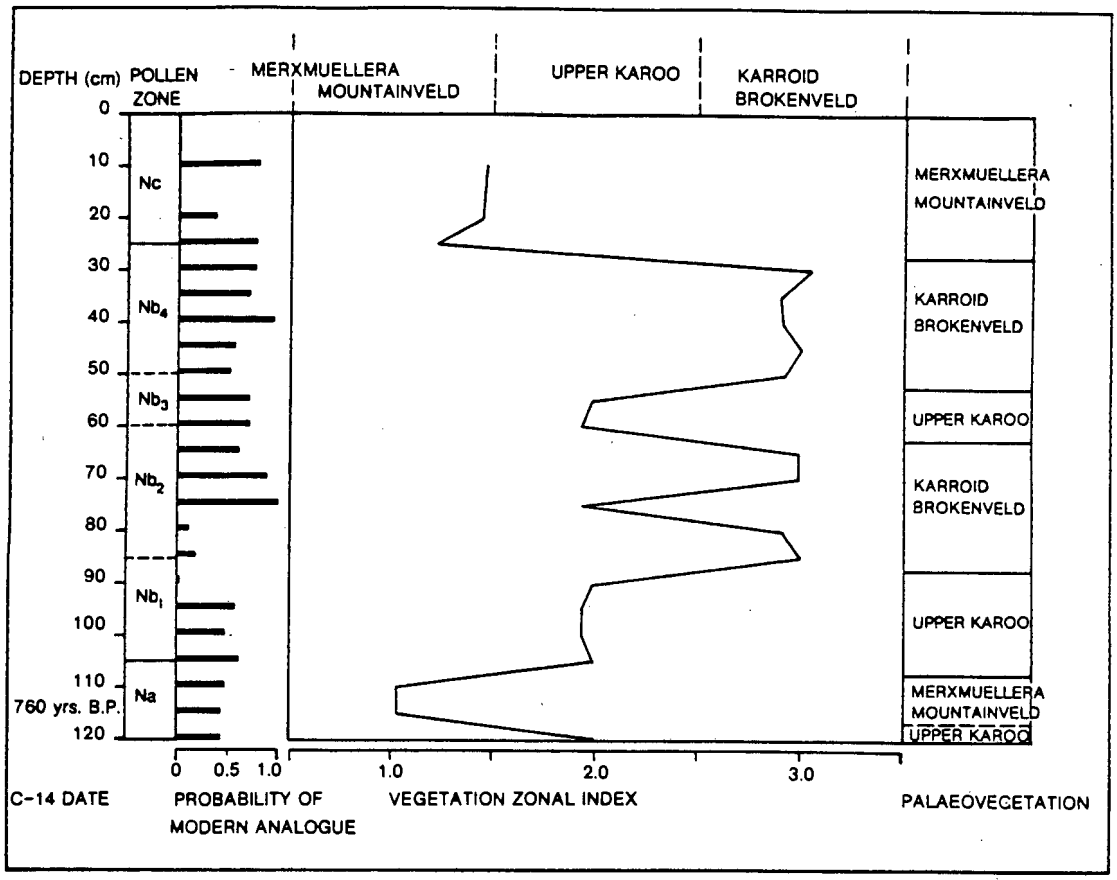

Figure 5.13 Results of discriminant analysis for the pollen stratigraphy from Bokkraal Vlei, Core 1.

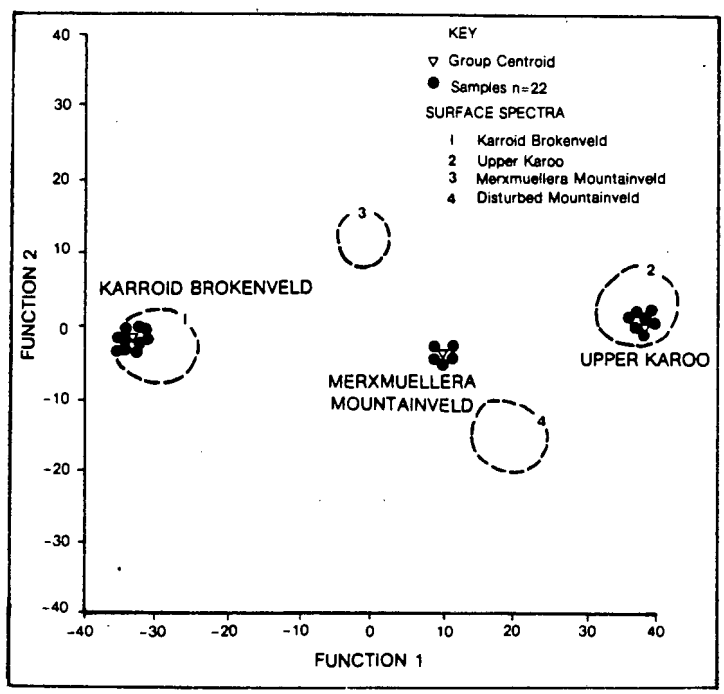

Figure 5.14 An ordination plot of the 22 fossil pollen samples from Bokkraal Vlei along discriminant functions 1 and 2. Dotted lines indicate the range of contemporary pollen spectra from four vegetation regions, which are superimposed for comparison.

modern samples and has a greater affinity to the "disturbed Mountainveld" than to pure Merxmuellera Mountainveld.

5.5 THE CEDERBERG RANGE.

5.5.1 CONTEMPORARY POLLEN STUDIES.

To check the representivity of the fossil pollen data, an analysis of the contemporary pollen spectra in the Cederberg area was undertaken. Few modern pollen studies have previously been undertaken in the fynbos vegetation (Van Zinderen Bakker and Coetzee, 1959; Schalke, 1973; Hawke and Meadows, 1988). Both sampling methods, viz. surface samples and pollen traps have been used.

i. Pollen Trap Spectra.

Fifteen pollen traps were placed in the Cederberg area for two consecutive years. Replication of the data was essential as some traps lost their acetate fibre. All 15 pollen traps were recovered in the first year (January 1987 - January 1988), but in the second year (January 1988 - December 1988) the acetate fibre was removed from three of the traps (C1, C12, C15). The data from the two seasons have been combined (Appendix J.7) and are represented in Figure 5.15.

a. Restioid Fynbos (C3, C4, C10, C11). These pollen traps are located in the vleis from which the cores were extracted, ie. C3 and C4 from Driehoek Vlei and C10 and C11 from Sneeuberg Vlei. The pollen spectra are dominated by Cyperaceae (15%), Restionaceae (25%) and Asteraceae (30%), as indeed are the local and surrounding communities. The spectra from traps located on 1m stakes (C3 and C10) have higher percentages of Bruniaceae and Asteraceae pollen than traps located at ground level (C4 and C11), which have greater percentages of Restionaceae and Cyperaceae pollen. Asteraceae and Bruniaceae are not usually found in the

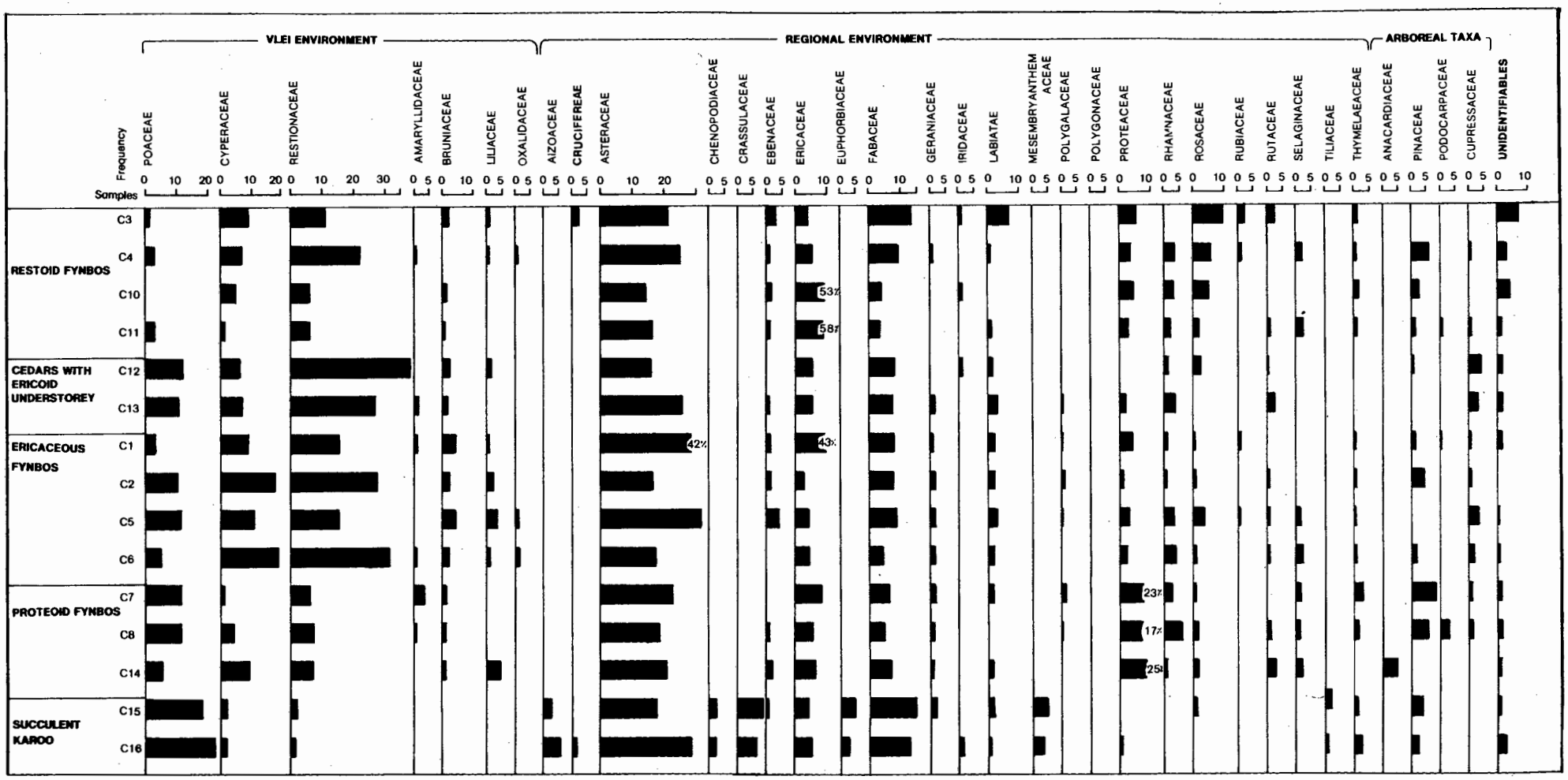

Figure 5.15 Cederberg pollen trap spectra from the 1987 and 1988 season.

vleis, but are part of the extralocal vegetation. Pollen from vlei elements contribute 60% of the total pollen in the traps at ground level (C4 and C11), whereas only 30% is contributed to the traps at 1m (C3 and C10). The arboreal element is low, with different types of arboreal pollen being present at the two sites. Traps C3 and C4, have a small percentage of Pinaceae pollen from a plantation some 2km away, whereas C10 and C11 have low percentages (2%) of *Widdringtonia cedarbergensis* pollen.

b. Cedars with an ericaceous understorey (C12, C13). The *Widdringtonia* which remain on the Cederberg are sparsely distributed and limited to the upper plateau and rocky outcrops. A modern pollen spectrum from dense cedar stands, which are thought to have covered the Cederberg Mountains in the past (Manders, 1986) is not available as they no longer occur in such abundance. Pollen traps have been erected in areas having a sparse canopy cover of *Widdringtonia* and an understorey dominated by Ericaceous shrubs. These pollen spectra (C12 and C13) are dominated by Restionaceae and Asteraceae pollen, with small percentages (4%) of *Widdringtonia*. The pollen trap at ground level has very little *Widdringtonia* pollen. Ericaceae, which forms the dense understorey has pollen frequencies of only 6.5% and appears to be under-represented.

c. Ericaceous Fynbos (C1, C2, C5, C6). The pollen spectra from C1 and C2 include a variety of pollen types, with the major contributions from Restionaceae, Asteraceae, Fabaceae and Rosaceae (*Cliffortia*), as indeed is the case in the vegetation. Although Ericaceae plants are abundant at the sites of traps C1 and C2, this is not reflected in the pollen spectrum. Pollen traps C5 and C6 are dominated by Ericaceae, which reaches a maximum percentage of 60%. The abundance of other fynbos shrubs in traps C5 and C6 is limited to a total of 14%, which includes Fabaceae, Proteaceae, Rhamnaceae and Rosaceae. The percentage of

Poaceae pollen is notably low in these pollen spectra, reaching a maximum of only 5%.

d. Proteoid Fynbos (C7, C8, C14). The pollen spectrum is composed predominantly of Proteaceae and Asteraceae pollen, with contributions from Poaceae, Ericaceae, Fabaceae and Rhamnaceae. Proteaceae pollen is under-represented as compared to the percentage cover in the area. The percentages of Cyperaceae pollen and other vlei elements is exceptionally low, while Poaceae percentages are notably higher (12%). The arboreal elements are represented by Pinaceae in C7 and C8. *Rhus* contributes to the pollen spectrum from the *Protea* grove (C14).

e. Succulent Karoo (C15, C16). These pollen traps are located in the Succulent Karoo, approximately 0.7km from the vegetation boundary of the Karoo and Fynbos Biomes. The vegetation from this assemblage is different from that of the previous fynbos assemblages. The pollen spectra are dominated by Poaceae, Asteraceae and Fabaceae. A number of typical Karoo taxa are present, including Aizoaceae, Chenopodiaceae, Crassulaceae (5%), Euphorbiaceae and Mesembryanthemaceae (3%). The transition to a Karroid vegetation is apparent from the high Poaceae percentages and the nominal contribution by Restionaceae, which is characteristic of fynbos.

ii. Surface Sample Spectra.

Surface samples were taken from the top 5cm of the soil at the base of each of the seven pollen traps for two consecutive years. These data (Appendix J.8) has been combined into a single diagram (Figure 5.16).

a. Restioid Fynbos (Cs4, Cs11). Samples Cs4 and Cs11 are taken from the surface of Driehoek and Sneeuberg vleis respectively. The local vlei elements (Poaceae, Cyperaceae and Restionaceae) contribute 55% (Driehoek) and 65% (Sneeuberg) of the total pollen spectrum, with Asteraceae,

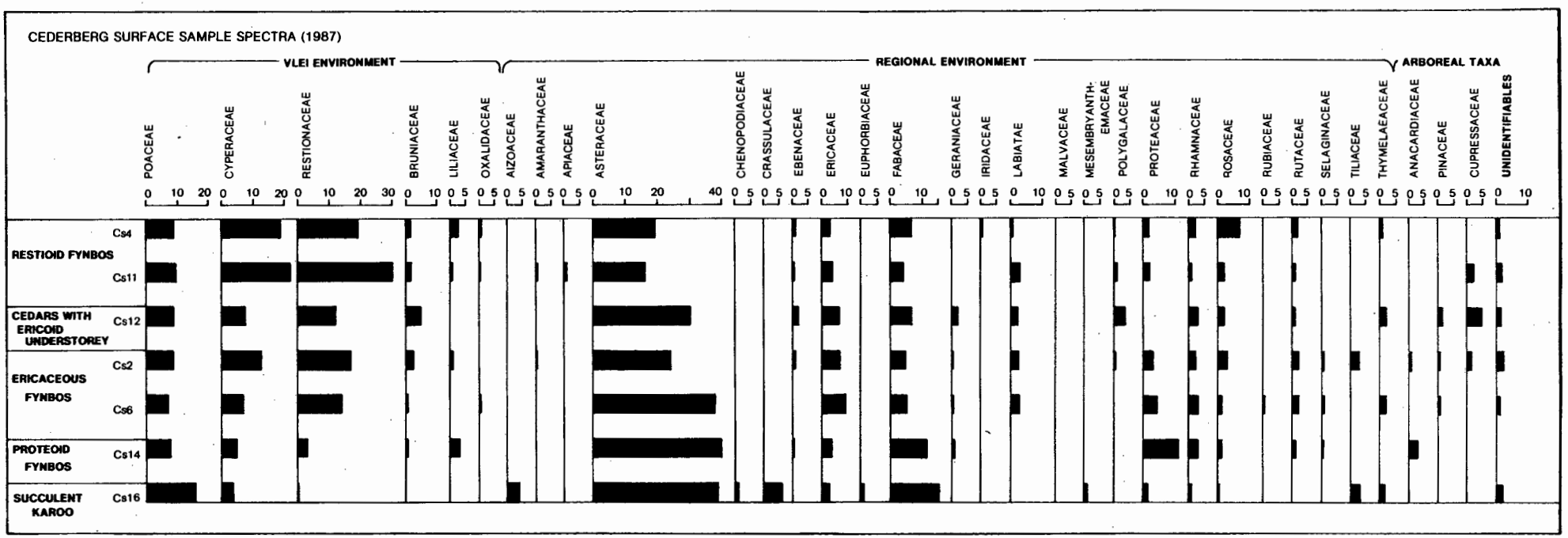

Figure 5.16 Cederberg surface sample spectra from the 1987 and 1988 seasons.

presumably from the regional environment, contributing to the remaining spectra.

b. Cedars with an ericaceous understorey (Cs12). This spectrum is dominated by asteraceous pollen (30%) and has a significant contribution of shrubby elements, including Ericaceae (14%), Fabaceae (5%), Polygalaceae, Proteaceae and Thymelaeaceae. *Widdringtonia* pollen is present in low percentages (3.5%), which is under-represented with regard to the canopy cover of these trees at the sampling point.

c. Ericaceous Fynbos (Cs2, Cs6). The pollen spectrum from the Ericaceous fynbos has high percentages of Asteraceae (28% in Cs2; 38% in Cs6) and relatively high frequencies of vlei elements. This is attributed to the location of a vlei adjacent to this sampling site. Ericaceae is under-represented in the pollen spectrum, as the percentage cover of this taxon approximates 80%.

d. Proteoid Fynbos (Cs14). This spectrum is dominated by Asteraceae pollen (40%) and has significant contributions of Poaceae (10%), Fabaceae (13%) and Proteaceae (12%) pollen. The contribution by vlei elements is lowest in this spectrum (20%). As is the case with most entomophilous taxa, Proteaceae are under-represented in the pollen spectrum (12%). *Protea nitida* forms a relatively dense canopy, with a shrubby understorey dominated by Asteraceae and Fabaceae.

e. Succulent Karoo (Cs16). Asteraceae pollen (40%) dominates Cs16, with significant contributions from Poaceae (13%), Crassulaceae and Fabaceae (15%). Pollen from a number of typical Karoo taxa appear, including Apiaceae, Chenopodiaceae, Euphorbiaceae and Mesembryanthemaceae. No arboreal pollen is present. Poaceae pollen appears to be over-represented in this sparsely vegetated area.

5.5.2 FOSSIL POLLEN STUDIES.

a. DRIEHOEK VLEI.

The results of the two cores taken in the Cederberg viz. Driehoek and Sneeuberg, are presented separately. The Driehoek pollen diagram (Figure 5.17) shows core stratigraphy, local pollen frequencies and regional pollen frequencies. The proportion of unknowns, which are divided into crumpled and broken types are relatively low, but increase to a maximum of 10% at a depth of about 320cm. The gap in the sequence between 280 and 320cm is a consequence of a very wet band of organic sediment, which could not be adequately sampled using the gouge auger.

i. Stratigraphy and Chronology.

The core from Driehoek Vlei extends to 520cm, which is the deepest continuous core yet taken from organic sediments or vleis using the gouge auger. The sediment stratigraphy is shown in Figure 5.17. The organic sediments, derived from substrates dominated by Table Mountain Sandstone, contain a large proportion of sandy quartz granules which are compacted and hamper the task of coring with a gouge auger. These sandy layers also have a lower organic content than the fine amorphous layers (Appendix I). Although no partially weathered bedrock was found at the base of the core, an impenetrable layer was reached, on which a fine black amorphous layer was deposited. This basal layer has an organic content of almost 19%.

The mean organic content for the entire core is 15.4% which is substantially higher than any core previously examined. The organic content of the sediments varies according to the texture, with the fine sediments having organic contents of c.19% and the coarser sediments at c.10%. The organic sediments also have markedly higher pollen densities (pollen grains per cm^3) than the coarser, sandy sediments. This feature is obvious when examining the sample at 515cm, which has an organic content of 18.9% and contains 22 680 grains per cm^3, whereas the sample at 220cm has an organic content

of 10.9% and contains only 8 310 grains per cm^3. The pollen concentration throughout the core is more or less consistently high and these sediments appear to be well suited to the preservation of pollen grains.

The sediments were dated by the CSIR using radiocarbon techniques. The basal sediments yielded an age of 14 600 ± 290 years BP (Pta-4523), an intermediate sample from 450cm is dated at 10 090 ± 100 years BP (Pta-4759) and the sample at 260cm is dated at 3 230 ± 70 years BP (Pta-4831).

ii. The Pollen Diagram.

To facilitate interpretation of the diagram, the local environment is distinguished from the regional and extralocal vegetation. This division has been made using contemporary pollen data and techniques identical to those indicated in section 5.4.2 for the Bokkraal pollen diagram.

Zonation of the diagram has been completed by detailed inspection of the pollen frequencies. The zone boundaries coincide with periods of increased pollen frequency fluctuation, such that the zones themselves are more or less contiguous or uniform pollen assemblages. Statistical analysis of the data sets has largely confirmed this subjective zonation, so it was retained to facilitate description of the vegetation history. No striking changes in pollen frequencies or sharp zone boundaries are evident.

Zone Da (520-495cm). The base of Driehoek core is characterised by slightly higher percentages of most vlei elements (Cyperaceae at 15%, Restionaceae at 16%, Labiatae, Amaryllidaceae and Liliaceae) than the overlying strata. Within the regional environment, slightly higher percentages of Bruniaceae (4%), Polygalaceae, Rubiaceae and Caryophyllaceae are recorded.

Zone Db (495-470cm). This zone is characterised by consistently high pollen percentages of vlei elements from

the local environment. Within the regional environment, Asteraceae peaks at 20% and then declines slightly and Proteaceae, Fabaceae and Geraniaceae increase slightly. *Widdringtonia* values are consistently elevated, displaying frequencies of up to 10%. The frequencies of Ericaceae, Rubiaceae and Santalaceae, which are presently abundant within the Ericaceous Fynbos are poorly represented.

Zone DcI, II and III (470-450cm; 450-370cm; 370-350cm). The bulk of the lower half of the pollen diagram is encompassed by three sub-zones (Dcl, Dcll, Dclll), which suggest vegetation changes too minor to warrant their individual detailed description. The local vlei environment displays consistent frequencies, indicating a stable local environment. Within the regional environment, a number of small fluctuations occur. Asteraceae, *Widdringtonia*, Thymelaeaceae and to a lesser extent Bruniaceae, have high pollen frequencies in zone Dcl, decline slightly in zone Dcll and then increase slightly in zone Dclll. Rosaceae (*Cliffortia*) however, displays the opposite trend of low frequencies in Dcl, an increase in Dcll and a decline in Dclll. *Stoebe*-types, Fabaceae, Rhamnaceae and Ericaceae all remain consistent in zone Dc.

Zone Dd (350-320cm). This zone is characterised by a slight increase in a number of pollen taxa, including *Stoebe*-types, Campanulaceae, Fabaceae, Proteaceae, Rutaceae and Thymelaeaceae and a consistently high frequency of *Widdringtonia*. Taxa from the local environment also display marked increases, including Poaceae, Cyperaceae and Labiatae frequencies.

Zone De I, II, III, IV (280-225cm; 225-90cm; 90-70cm; 70-50cm). The bulk of the upper half of the pollen diagram is encompassed within this zone, which is subdivided into four sub-zones (Del, Dell, Delll, DelV). These sub-zones show fluctuating pollen frequencies which are too minor to warrant detailed descriptions. The vlei environment pollen

taxa remain consistently high, with Poaceae being more abundant in zone DelV than Del1. *Stoebe*-types decline in zone Del11. Aizoaceae and Crucifereae occur at frequencies of 1.5% and 2.5% respectively in zone Del11, whereas Proteaceae decreases slightly in zone Del11 and DelV. Myricaceae pollen occurs for the first time in Zone Del1, whereas the other arboreal element, *Widdringtonia*, has frequencies of 8% at the base of zone Del and declines progressively in zone Del11 and DelV to frequencies of only 1.5%.

A number of minor fluctuations have been noted in this zone and although they appear to be insignificant when examined individually, they are of more use when examined together as a community. Zone Del is characterised by an Ericaceous Fynbos, with an abundance of cedars which are progressively reduced with time. Zone Del11 is characterised by an increase in Asteraceae, a small peak in Aizoaceae and Santalaceae and poor representation of Bruniaceae and Rosaceae.

Zone Df (50-0cm). The uppermost zone is characterised by an increase in a number of vlei elements, including Liliaceae, Juncaceae, Ranunculaceae and a marked decrease in Poaceae. Fluctuations in the regional environment are also noted, particularly the net decrease in Asteraceae, but slight increase in *Stoebe*-type as well as the following taxa: Proteaceae, Rosaceae, Rutaceae and Thymelaeaceae. The almost negligible frequencies of *Widdringtonia* are also noted.

B. SNEEUBERG VLEI.

The Sneeuberg pollen diagram (Figure 5.18) shows core stratigraphy, pollen concentrations, local and regional pollen frequencies. The different pollen types identified in the core are similar to those of the contemporary pollen samples.

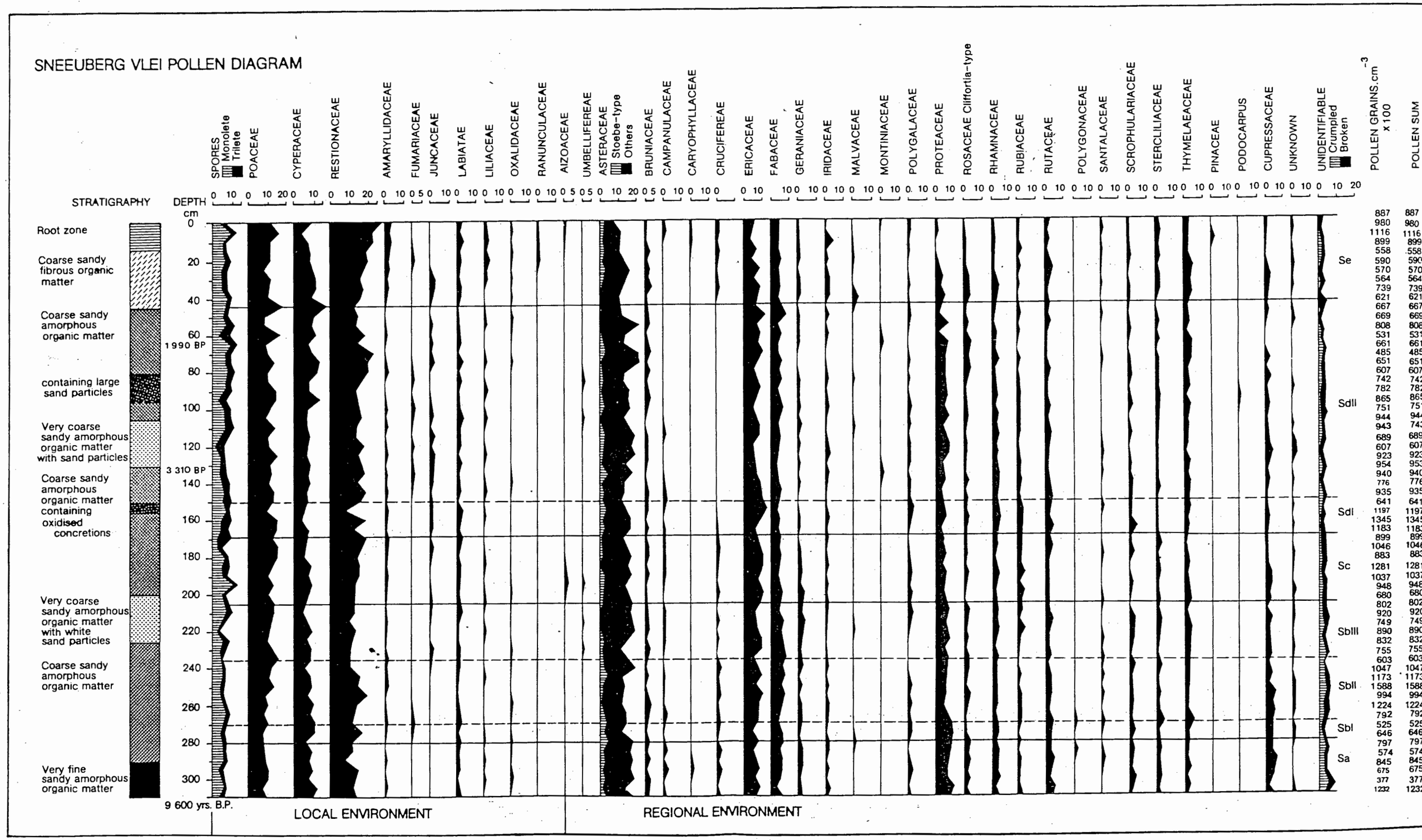

Figure 5.18 Sneeuberg pollen diagram from the Cederberg Range.

i. Stratigraphy and Chronology.

The sandy, compacted organic sediments limited coring to a depth of 310cm. The sediments form a stratigraphically continuous sequence. Underlying the fine amorphous organic matter at 310cm is an impervious sandy layer. The fine sediments at the base of the core had a high organic content of almost 23%. The mean organic content for the core was 18.8%, which is the highest value encountered in the entire study (Appendix I). The coarse sandy organic sediments had a lower organic content of c.16%. The density of pollen grains does not appear to be influenced by the organic content of the sediments as was the case in the Driehoek core.

Using radiocarbon dating techniques, the basal samples have been dated at 9 640 $\pm$ 70 years BP (Pta-4522). A sample from 65cm is dated at 1 990 $\pm$ 80 years BP (Pta-5029) and another at 133cm is dated 3 310 $\pm$ 90 years BP (Pta-5007). The sediment follows a stratigraphic sequence with no unconformities and shows a logical chronological sequence.

ii. The Pollen Diagram.

Few striking changes in pollen frequencies are apparent in this pollen diagram. It is zoned using conventional visual zoning, which is then re-assessed using numerical techniques.

Zone Sa (310-280cm). The local vlei elements are present in relatively high percentages, particularly Restionaceae at 13%, Labiatae (*Mentha aquatica*) and Oxalidaceae. The regional environment is characterised by high percentages of Asteraceae (19%), Bruniaceae (4%), Proteaceae (10%), *Widdringtonia* and a small peak in Caryophyllaceae.

Zone SbI, SbII, SbIII (280-270cm; 270-235cm; 235-205cm). These fluctuations are too minor to warrant detailed individual descriptions. Within this zone, consistently high pollen frequencies are apparent for the dominant vlei

taxa. In the regional environment, there are a number of small fluctuations in pollen frequencies, along with consistently high frequencies of Ericaceae and Fabaceae. Asteraceae frequencies decrease in zone Sb1, remain relatively low in Sb11 and increase slightly again in zone Sb111. The frequencies of Proteaceae, Polygalaceae, Thymelaeaceae and *Widdringtonia* remain relatively high, indicating conditions similar to the underlying zone. In zone Sb11 the Proteaceae frequencies decline, while *Widdringtonia* frequencies remain high (5%). In zone Sb111 there is an increase in Asteraceae frequencies, but a decline in the proportion of *Stoebe*-types and Umbelliferae pollen is recorded for the first time.

Zone Sc (205-170cm). Pollen frequencies from vlei taxa remain consistent, but notable fluctuations occur within the regional pollen types. Aizoaceae pollen is recorded for the first time. Other changes include a slight increase in Ericaceae and Sterculiaceae and a decline in the Proteaceae and Thymelaeaceae frequencies.

Zone SdI, SdII (170-150cm; 150-45cm). The bulk of the upper half of the diagram is encompassed within this zone. In sub-zone Sd1 the local environment is characterised by an increase in trilete spores, Fumariaceae and Labiatae, and an associated decrease in Restionaceae and Cyperaceae percentages. In sub-zone Sd11 the percentages of vlei element pollen stabilise and consistent frequencies of Poaceae and Restionaceae pollen are apparent. Within the regional environment, sub-zone Sd1 is characterised by increases in Ericaceae, Polygalaceae and Rutaceae. Sub-zone Sd11 shows consistency in most taxa, with slight increases in the pollen frequencies of Proteaceae, Rutaceae and Rhamnaceae, and both Montiniaceae and *Podocarpus* occur for the first time at low frequencies.

Zone Se (45-0cm). The vlei environment is characterised by a decline in the frequency of Cyperaceae pollen and an

increase in a number of taxa including Restionaceae, Amaryllidaceae, Labiatae and Ranunculaceae. The regional environment is characterised by a number of changes, the most notable being the decline in Asteraceae, Ericaceae, Proteaceae and *Widdringtonia* and corresponding increases in the frequencies of the following taxa: *Stoebe*-type, Caryophyllaceae, Crucifereae, Rutaceae, Thymelaeaceae and Pinaceae occurs for the first time. It is interesting to note that many of the taxa which have increased frequencies in this zone have members which are "weedy" in nature, or perform well after fires.

5.5.3 MULTIPLE DISCRIMINANT ANALYSIS.

i. Contemporary Vegetation-Pollen Relationships.

Discriminant functions are derived which classify all contemporary pollen samples from known vegetation assemblages on the Cederberg into one of the following *a priori* groups: Proteoid Fynbos, Ericaceous Fynbos, Restioid Fynbos, cedars with an ericaceous understorey and Succulent Karoo. Within the pollen trap spectra, the variation between pollen assemblages is accounted for by discriminant function 1 (99.88%), function 2 (0.11%) and function 3 (0.01%). In the case of the surface sample spectra, two discriminant functions accounted for 99.88% and 0.12% of the total variation. The *a priori* group membership is compared to the objectively predicted membership and indicates that 100% of the pollen trap samples and 71.43% of the surface samples are correctly classified.

The discriminant scores for the 15 pollen trap spectra and 7 surface sample spectra are plotted along the first two discriminating functions in Figure 5.19 and Figure 5.20. These ordination plots show that samples have little variation about their group centroid, yet the five centroids are not distinctly separated from one another. The vegetation communities all have similarities, except the Succulent Karoo, which is distinctly different from the

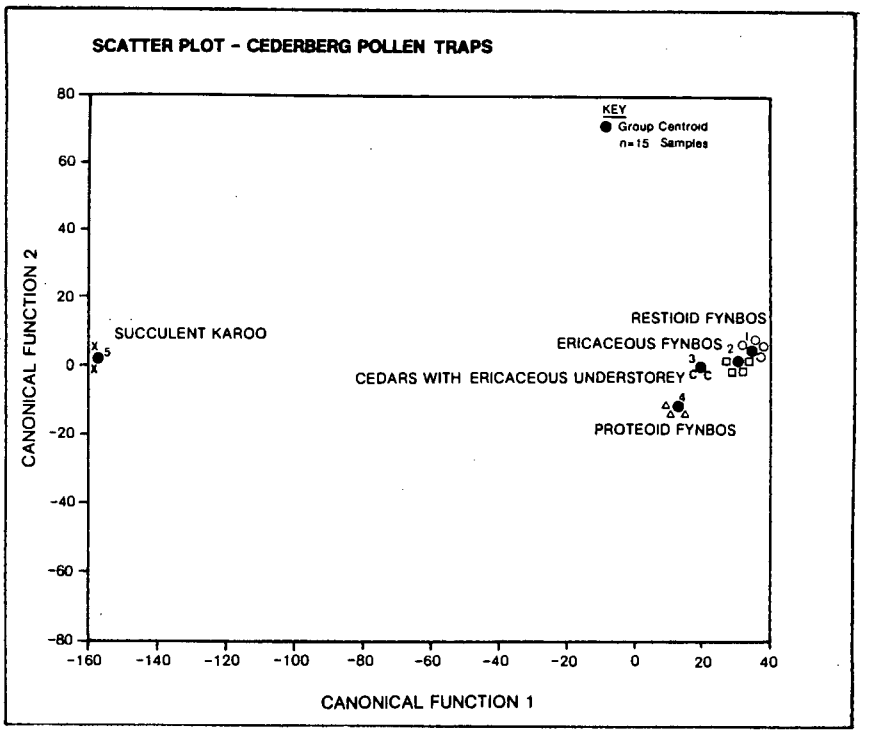

Figure 5.19 Ordination plot of the pollen trap samples from the Cederberg, plotted against discriminant functions 1 and 2.

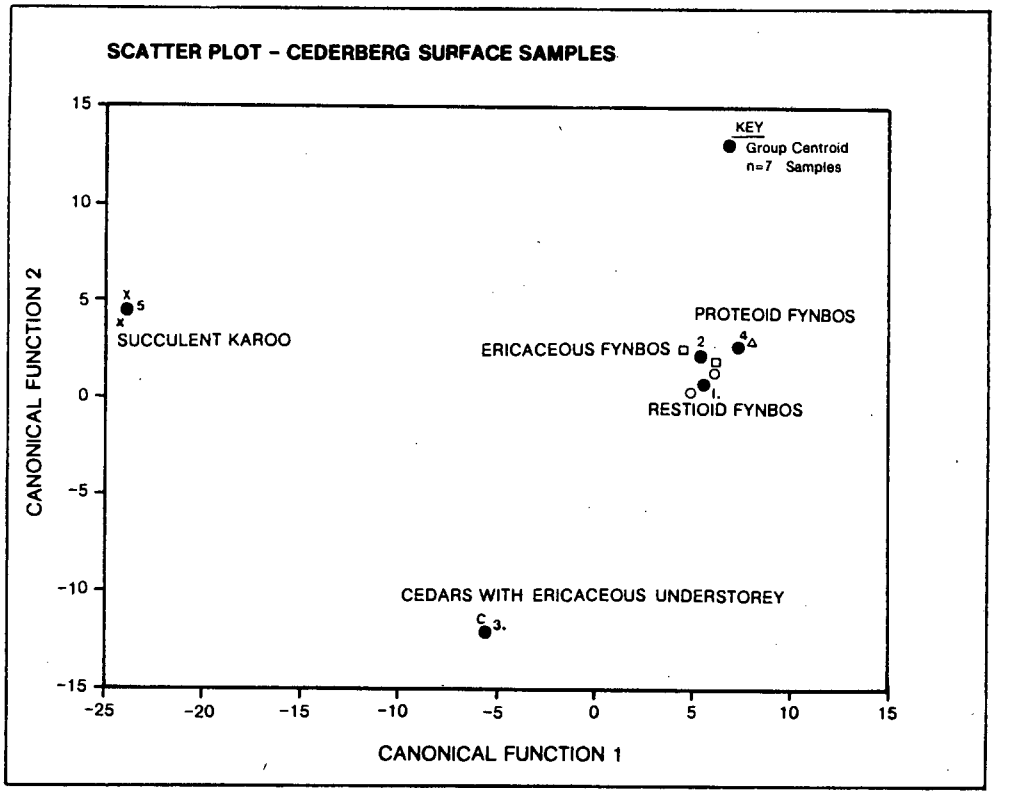

Figure 5.20 Ordination plot of the surface samples from the Cederberg and plotted against discriminant function 1 and 2.

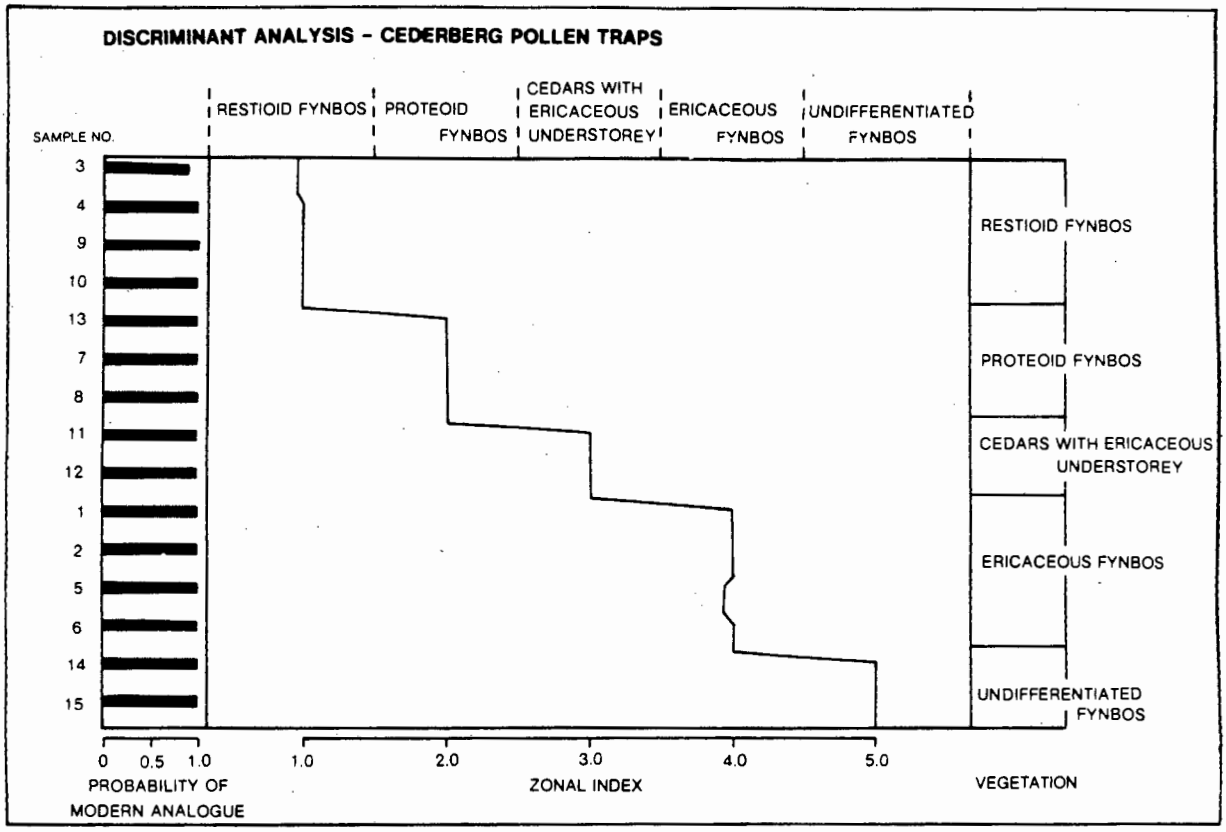

Figure 5.21 Results of discriminant analysis, showing the zonal indices and modern analogues for the pollen trap data.

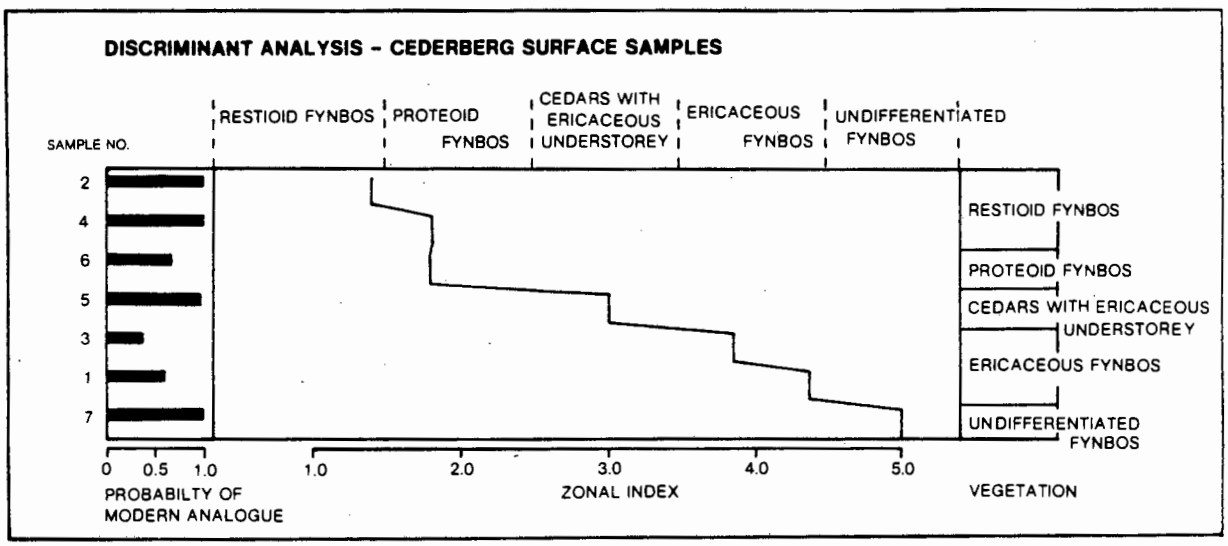

Figure 5.22 Results of discriminant analysis for the surface samples from the different vegetation assemblages.

fynbos assemblages.

a. *Vegetation Zonal Index.* The probabilities of group membership for the predicted and second most probable groups of variables are calculated for each of the modern pollen samples. These probabilities reflect the zonal pattern of the vegetation along a gradient and are converted to a single vegetation zonal index as explained in section 5.4.3(ii). The contemporary pollen spectra typical of the vegetation regions are assigned specific zonal indices corresponding to the vegetation assemblage along the gradient ie. Restioid Fynbos, Proteoid Fynbos, cedars with an ericaceous understorey, Ericaceous Fynbos and Undifferentiated Fynbos or Succulent Karoo are assigned indices of 1.0, 2.0, 3.0, 4.0 and 5.0 respectively. The vegetation zonal indices for pollen trap spectra (Figure 5.21) and surface sample spectra (Figure 5.22) all approximate 100%, as the samples are from known vegetation assemblages. The surface sample at sampling point 1, from Ericaceous Fynbos, is atypical of this assemblage. Restioid Fynbos samples (numbers 4 and 6) are misclassified and have affinities for Ericaceous Fynbos. Although it appears from Figure 5.22 that they are reclassified as Proteoid Fynbos, they have greater similarities with Ericaceous Fynbos, which has a zonal index of 4.0. This poor representation is a function of the ordering of the vegetation assemblages along the gradient from 1.0 to 5.0.

Probability of a Modern Analogue. This probability index compares a pollen assemblage with the "palynological signature" of its assigned vegetation region, as represented by the group centroid. All pollen trap spectra have probabilities which approximate 1.0 (Figure 5.21). This probability should be high, as samples are taken from contemporary assemblages which are well represented in the Cederberg area. The modern analogue probabilities from surface samples (Figure 5.22) are lower, particularly for samples 1 and 3.

ii. Fossil Pollen Studies.

The probabilities of modern analogues and vegetation zonal indices are calculated for each fossil pollen spectrum in the same way as for contemporary data. These values are plotted stratigraphically for the pollen sequence of Driehoek Vlei and Sneeuberg Vlei.

A. DRIEHOEK VLEI.

Discriminant functions are derived which classify the fossil pollen samples from unknown vegetation regions into one of the five *a priori* groups. The variation within the fossil pollen data is accounted for by three discriminant functions, which account for 89.48%, 8.85% and 1.02% of the variance. A comparison of the *a priori* group membership and the predicted group membership show that 62% of the samples are correctly classified.

Vegetation zonal indices. Zonal indices are calculated for the fossil subsamples using the same techniques as used for contemporary pollen samples and plotted in Figure 5.23. Incorrectly classified samples are identified where *a priori* vegetation assemblages along the horizontal axis do not correspond with predicted palaeovegetation categories in the right-hand column, for example, the sample at 260cm. The basal sediments of zone Da (475 - 520cm) and zone Dd are characterised by fluctuating frequencies of Proteoid and Restioid Fynbos. These fluctuations show the varying abundance of Restioid Fynbos in relation to the Proteoid canopy cover. In zone Dc11 the zonal index seldom reaches 3.0, but fluctuates around 2.5, indicating that although this palaeovegetation is classified as "cedars with an ericaceous understorey" it has a high percentage of Proteaceae plants contributing to canopy cover.

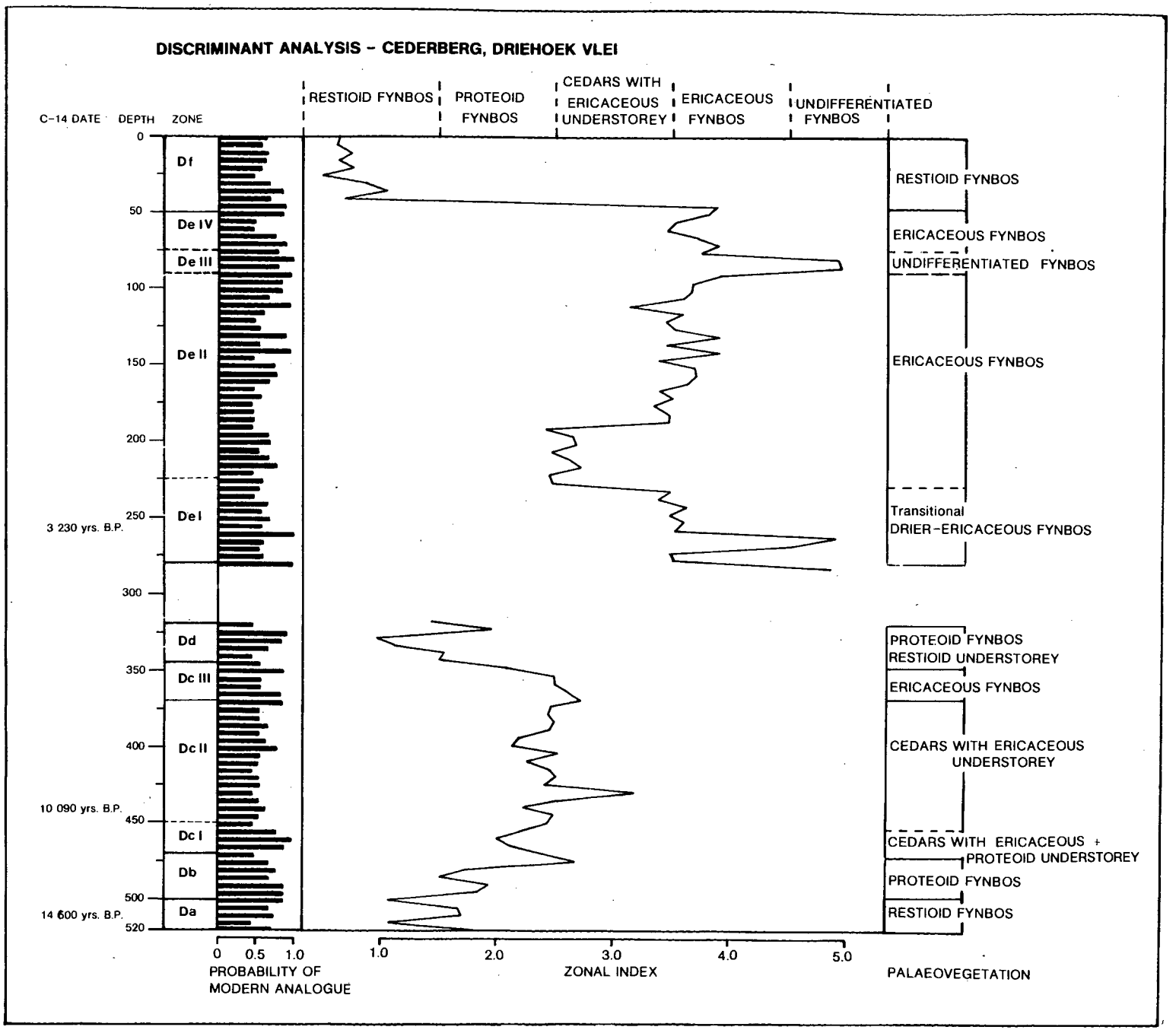

Figure 5.23 Discriminant analysis results from the pollen stratigraphy from Driehoek Vlei.

In zone De the zonal index fluctuates between Ericaceous and Undifferentiated Fynbos, representing a transitional Ericaceous Fynbos. For the greater part of the upper half of the diagram, Ericaceous Fynbos dominates, except for the base of zone Dell, where the overstorey of *Widdringtonia* is significant. At a depth of 75cm (Delll) there is a marked fluctuation, with Undifferentiated Fynbos predominating. The uppermost zone is characterised by Restioid Fynbos, which has an index of 1.0 and shows no sign of an affinity towards *Widdringtonia* as is apparent in zone Da.

Probability of a Modern Analogue. Palaeovegetation types inferred from fossil pollen assemblages and without modern analogues are detected by computing the probability of a modern analogue. The probability of a modern analogue is high when the zonal index approximates 100% similarity to a particular vegetation assemblage, for example, at 280cm the zonal index is 5.0 and the probability of a modern analogue is 1.0. For the most part, these probability values are between 0.5 and 1.0.

To augment the interpretation of Figure 5.23, the discriminant scores for the fossil pollen spectra from Driehoek Vlei are plotted along the first two discriminant functions (Figure 5.24). This ordination plot separates the centroids of the different vegetation assemblages, but the rest of the samples are not clustered around their particular group centroid. Undifferentiated fynbos has high modern analogue probabilities and forms the most distinct group but, in general, no really clear pattern distinguishing discrete vegetation assemblages emerges.

B. SNEEUBERG VLEI.

The fossil pollen samples from unknown vegetation regions are classified using discriminant functions, into one of the five *a priori* groups. The first three discriminant functions account for 80.99%, 15.72% and 4.29% of the variation within the fossil pollen data.

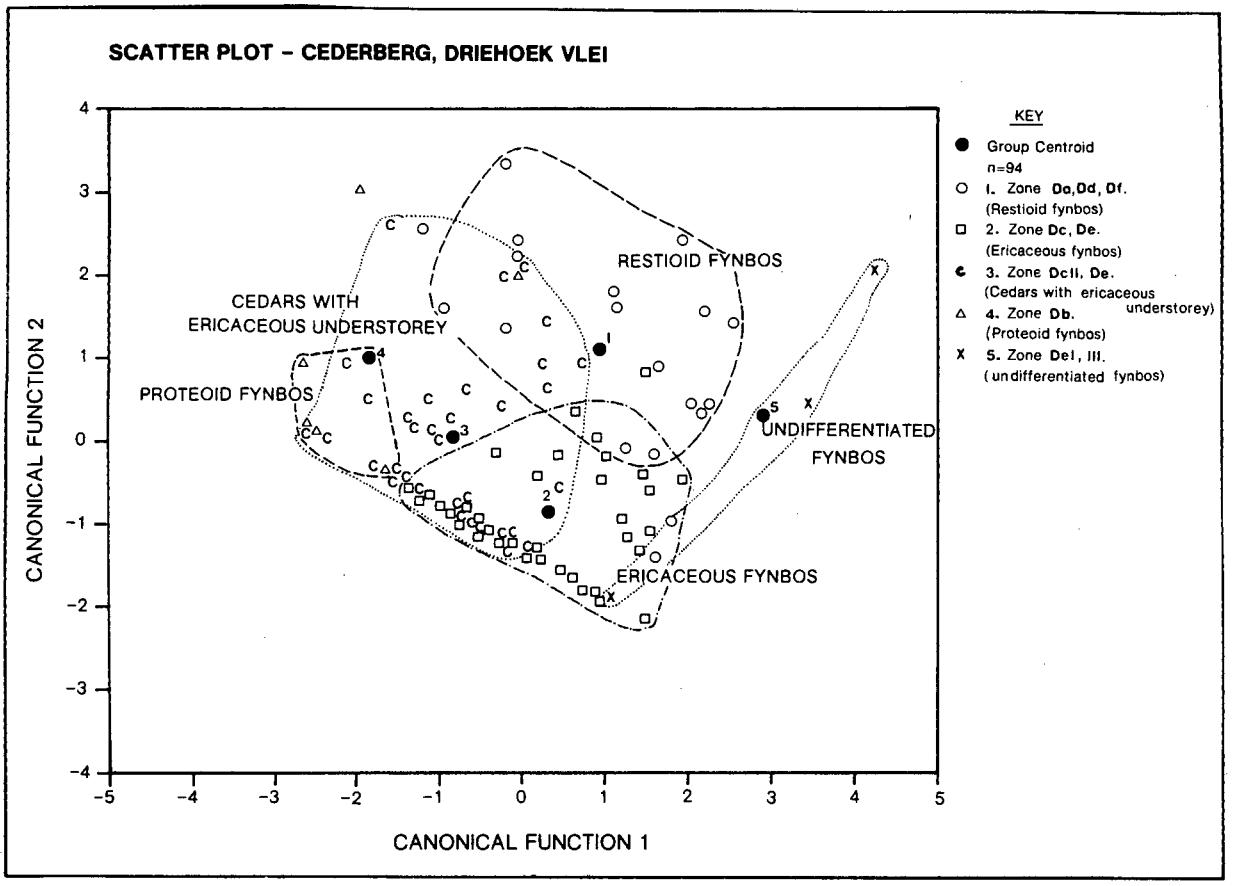

Figure 5.24 Ordination plot of the fossil pollen samples from Driehoek Vlei along discriminant functions 1 and 2.

The vegetation zonal index. This index is calculated for each of the 63 fossil samples in the same way as for the surface samples. These values are plotted stratigraphically for the pollen sequence from Sneeuberg Vlei (Figure 5.25). The stratigraphic changes in these probabilities and indices are then interpreted in terms of vegetation change. A comparison of the *a priori* group membership and the objectively predicted group membership indicates that 84.13% of the fossil samples are correctly classified. The incorrectly classified samples are identified in Figure 5.25 as they are located at a point on the curve where the *a priori* vegetation assemblage on the x-axis does not correlate with the palaeovegetation category on the y-axis.

Zone Sa has a vegetation zonal index of 1.75 and the vegetation occurring in this catchment at about 9 600 BP is best described as Proteoid Fynbos. This assemblage has some affinities with Restioid Fynbos, which has a zonal index of 1.0. The vegetation zonal indices change to 3.0 in zone Sb, showing a change to Ericaceous Fynbos which has a canopy cover of Proteaceae in zone Sb1, and an overstorey of *Widdringtonia in zone Sb11. Zone Sc has vegetation zonal* indices approximating 5.0, which represents Undifferentiated Fynbos. This is followed by a transitional phase and hence the low probability of modern analogues. Zone Sd11 is characterised by zonal indices which approximate 4.0, representing Ericaceous Fynbos. The uppermost layer or zone Se has a zonal index of 1.0 which is representative of a Restioid Fynbos. This Restioid Fynbos has a zonal index of 1.0 and has few similarities with Proteoid Fynbos or the *Widdringtonia* with an ericaceous understorey.

Probability of a Modern Analogue. These probabilities are high within each zone but decrease during the interzonal stages. The probabilities of a modern analogue are low in zone Sb, where the predicted palaeovegetation is an ericaceous understorey with a canopy cover of cedars and Proteaceae. In zone Sd the probability of a modern analogue is high, which indicates that the Ericaceous Fynbos which prevailed was very similar to that of the present Ericaceous Fynbos region.

The discriminant scores for the first two discriminant functions are plotted in Figure 5.26. Three vegetation assemblages are distinguished:(i) Restioid Fynbos; (ii) a combination of Ericaceous and Undifferentiated Fynbos and (iii) a combination of Proteoid Fynbos and cedars with an understorey of Ericaceous Fynbos. According to the zonal gradient in Figure 5.25, Undifferentiated Fynbos (5.0) is adjacent to Ericaceous Fynbos (4.0) and cedars with an ericaceous understorey (3.0) are adjacent to Proteoid Fynbos

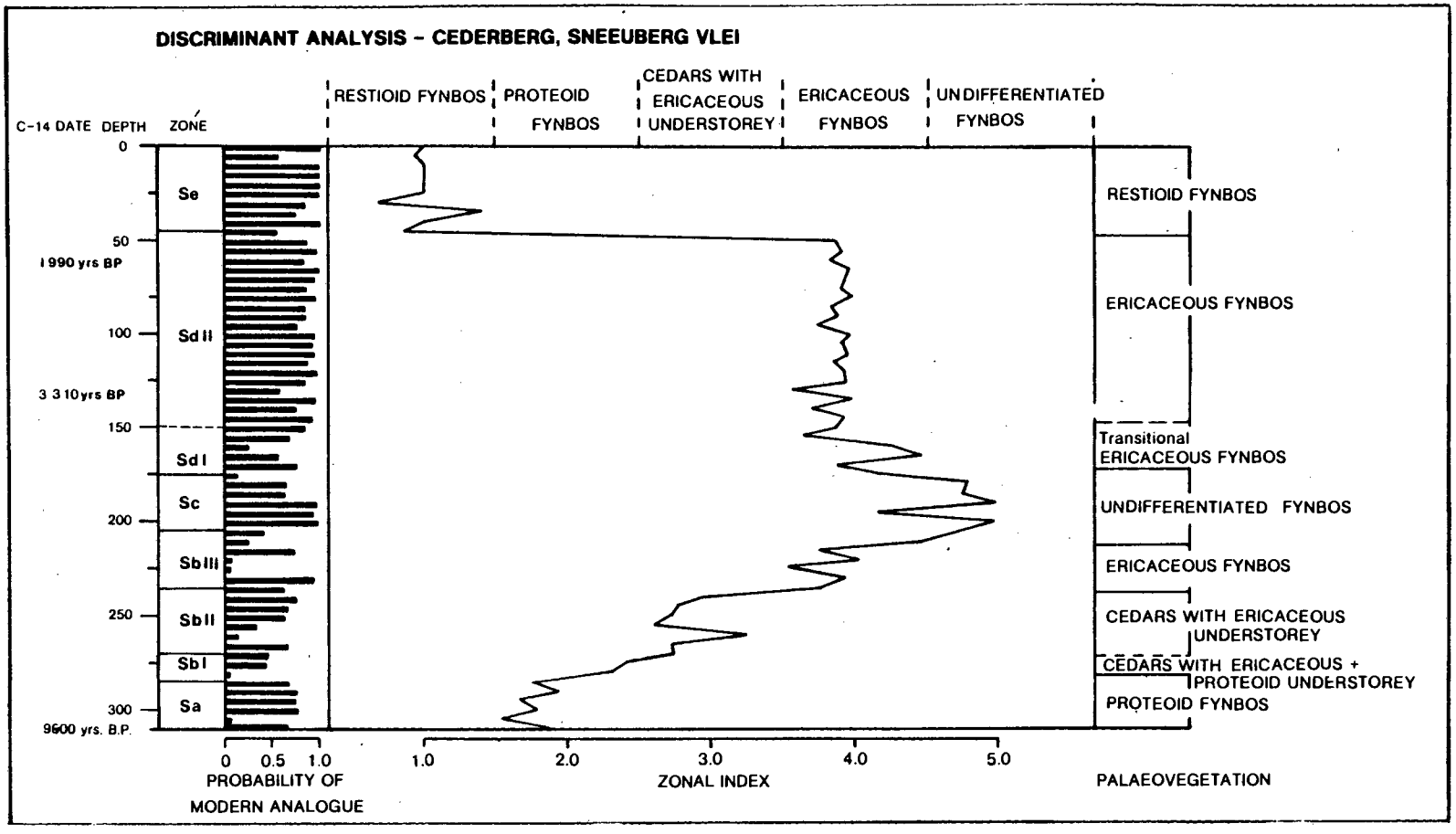

Figure 5.25 Discriminant analysis results from the pollen stratigraphy from Sneeuberg Vlei.

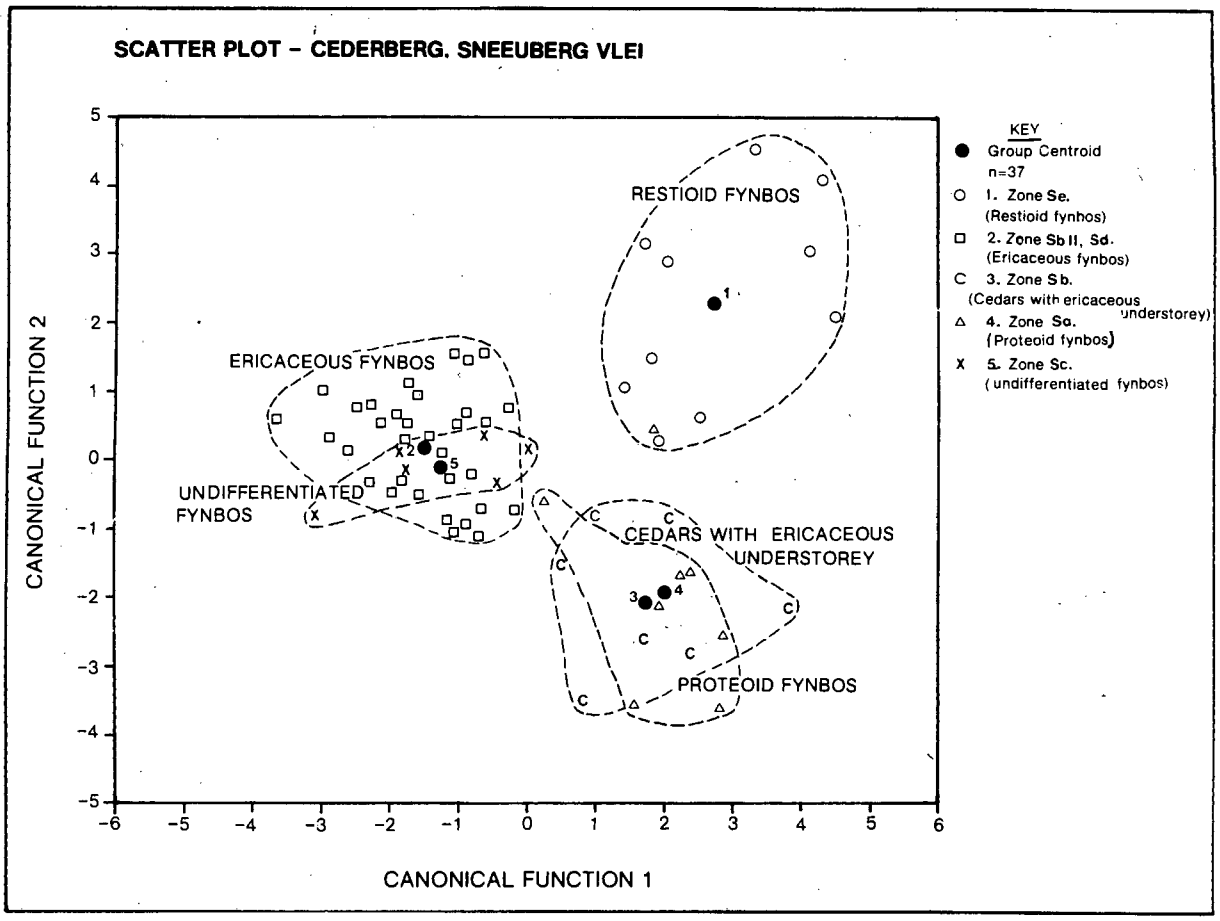

Figure 5.26 A scatter plot of the fossil pollen samples from Sneeuberg Vlei.

(2.0) and overlap occurs between assemblages. The modern analogue probabilities are low for the ecotonal areas between Ericaceous and Undifferentiated Fynbos and, once again, between Proteoid Fynbos and cedars with an ericaceous understorey. The ordination plot shows that these vegetation assemblages are complex and have affinities for each other. In addition, some taxa occur in more than one vegetation assemblage and well defined groups are therefore not formed.

5.5.4 TWISA.

i. Driehoek Pollen Spectrum.

Pollen spectra from samples at random depths within Driehoek core were classified by TWISA to form a dendrogram (Figure 5.27). In some instances consecutive samples are grouped together, showing that they have close similarities and form

a single group or zone. In this case samples 1 and 2 form zone 1. This dendrogram shows 9 zones within the pollen diagram, but only 5 different vegetation assemblages eg. zones 6 and 9 are the same vegetation type but occur at different depths in the pollen diagram. The five different vegetation assemblages are derived from the modern pollen samples and are assumed to be Restioid Fynbos, Ericaceous Fynbos, Proteoid Fynbos, Undifferentiated Fynbos and cedars with an ericaceous understorey.

ii. Sneeuberg Pollen Spectrum.

Pollen samples are taken from random depths within the Sneeuberg Core and classified to form this dendrogram (Figure 5.28), which shows the relationship between samples. The dendrogram identifies six different zones or groups in the Sneeuberg pollen diagram, although there were only two different groups, or in this situation, vegetation assemblages, prevailing during the past 9 600 years.

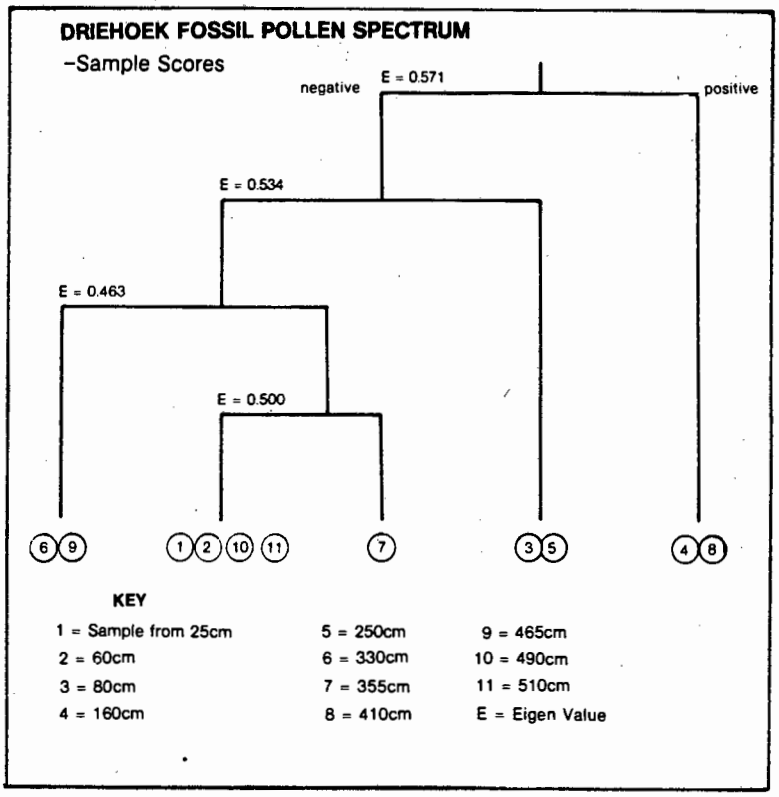

Figure 5.27 Dendrogram showing the classification of fossil pollen samples taken at random depths from the Driehoek pollen stratigraphy.

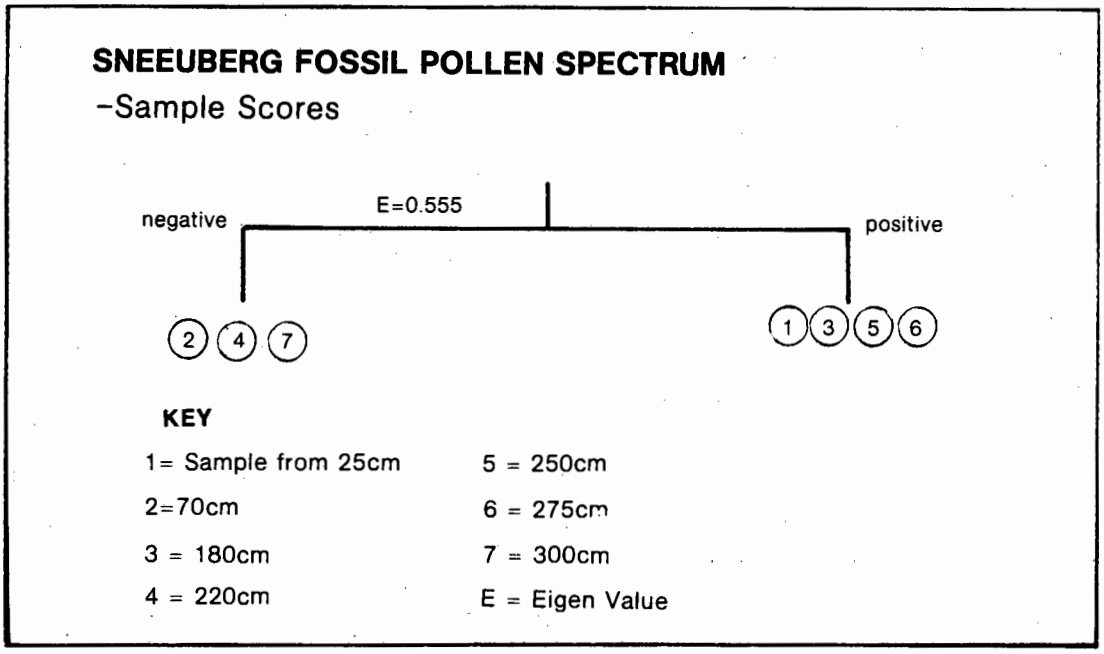

Figure 5.28 Dendrogram showing the classification of fossil pollen samples taken at random depths from the Sneeuberg pollen stratigraphy.

5.6 SCANNING ELECTRON MICROSCOPY.

5.6.1 GENERAL POLLEN MORPHOLOGY.

Brief descriptions of the pollen morphology of each of the selected taxa are given. Many are similar to those of Erdtman (1943), Van Zinderen Bakker (1953, 1956) and Van Zinderen Bakker and Coetzee (1959) which were described on the basis of light microscopy, but additional detail regarding the exine surfaces, perforations and size of the grains, obtained by SEM, are given here. SEM proved to be useful for differentiating between problem taxa, particularly *Stoebe* and *Elytropappus*, Poaceae and Restionaceae and Chenopodiaceae and Amaranthaceae. The species are arranged according to their importance with regard to differentiating the "problem" taxa.

i. **Asteraceae** : *Stoebe vulgaris* Levyns (Plate 5.1)
Stoebe aethiopica L. (Plate 5.2)
Elytropappus rhinocerotis (L.F.) Levyns (Plate 5.3).

The pollen morphology of this family has been described previously by Wodehouse (1935), Erdtman (1943), Van Zinderen Bakker (1953), Moore and Webb (1978) and that of subtribes Scorzonerinae and Lactuceae by Blackmore (1982), and by Blackmore and Clagher (1987) and Blackmore and Barnes (1987) respectively.

The pollen grains all have well developed spines which present the appearance of uniformity in size, distribution and density over the surface. The spines are short, broad-based and usually taper into a more or less acuminate tip. The length of the spines and their distance apart varies in the different species. According to Erdtman (1943) these measurements may be used to distinguish genera. The exine has a granular texture, but surrounding the base of the spine the texture is coarser, whereas the upper shaft is smooth.

The aperture system is trizonocolporate and in longitudinal section these grains are prolate in shape. They have a coarse network of echinae, which are not separated by lacunae as found in the Scorzonerinae. The tectal surface of these three taxa is echinate. The echinae of *S. aethiopica* (Plate 5.2) are 1.8µm in length, have a larger base and are less dense (60-80 spines per grain) than those of *S. vulgaris* (Plate 5.1), which are 1.5µm long, have a smaller base and are more abundant (230-250 spines per grain). The echinae of *Elytropappus rhinocerotis* (Plate 5.3) are less than 1.3µm in length and are abundant (150-200 spines per grain). *E. rhinocerotis* is subechinate, whereas *Stoebe* spp are echinate. The outline of the grains under the light microscope (LM) appears to be undulating because the echinae are broad-based. The spine cavities or holes piercing the exine surface at the base of the spines (Salgado-Labouriau, 1982) are present in these species. *S. aethiopica* and *S. vulgaris* have a row of spine cavities at the base of the spine, with those of *S. vulgaris* being less abundant. *Elytropappus* has fewer and less distinct spine cavities than those of *Stoebe*.

The exine varies in thickness over the surface of the grain giving the tectum an undulating appearance. The exine is thicker in the centre of the mesocolpium. No solid tectum is apparent. The echinae and the layer underneath them appear to be traversed by fine rods. Connections between the solid nexine and this structured, echinate tectum is usually rudimentary or absent. Columellae are absent and endocolpi form a complete equatorial girdle.

Three well-defined sunken colpi are present, with those of *Elytropappus rhinocerotis* being rounded and well defined. The compound apertures comprise an ectoaperture consisting of a meridionally elongated colpus with rounded ends; a lalongate to porate mesoaperture and a lalongate endoaperture. In fresh grains an operculum of resistant material covers the meso- and endoapertures. The swelling

at the pores of *S. aethiopica* is due to the extrusion of material from within the resistant exine and is not a diagnostic feature.

ii. **Poaceae** : *Pentameris macrocalycina* (Steud.) Schweick (Plate 5.4).

Descriptions of this family are documented by Erdtman (1943), Van Zinderen Bakker (1953) and Kohler and Lange (1979). The grains are monads (monoaperturate) and have a spheroidal to ovoidal shape. The outline is ellipsoidal with a single pore (ulcus), which is raised above the surface.

The size of *Pentameris* grains range from 35 to 55µm. The diameter of the pore ranges from 2.8 to 4.0µm. The pore is surrounded by a thickened rim (annulus) which causes the pore to be raised. The pore is crossed by a delicate membrane bearing a conspicuous operculum at or near the centre. The operculum has the same granular-microverrucate exine as the rest of the grain. The annulus is composed of three layers: the ektine and endexine, which in optical section are separated from each other, and a third "mesexinous" layer which fills the space between the ektine and endexine. The grains have a densely granular to verrucate sculpturing. The surface ornamentation of microverrucae is dense and of uniform density throughout the exine. The absence of scrobiculi, the structure of the interapertural wall and the absence of granules within the aperture are the diagnostic features of Poaceae.

ii. **Restionaceae** : *Restio filiformis* Pior. (Plate 5.5).

Descriptions of this family are documented by Linder (1984; 1985). These monad pollen grains vary in shape from depressed ovoid to spheroidal. The outline is ellipsoidal, with the pore raised above the surface. Their size varies from 40 to 65µm, but Linder (1984) notes this is not a reliable characteristic as it varies markedly. The grains have a verrucate-subrugulate surface, which is gently

undulating and pierced by scrobiculi located in the hollows (Linder, 1984). The surface ornamentation of microverrucae (0.15µm in diameter) is sparse, being 1 to 2 diameters apart. The minutely scrobiculate ornamentation of the exine distinguishes Restionaceae from Poaceae. Additional distinguishing features are documented by Linder (1984).

The interapertural wall is 1 to 3µm thick and under the LM the sexine and nexine are distinguishable. The sexine (ektexine) consists of tectum, columellae and foot layer. The details of these layers are described by Moore and Webb (1978, p.33). The surface of the foot layer is smooth, but tectal projections occur on the interapertural walls, eg. *Ischyrolepis sieberi* (Plate 5.5D). An endexine occurs in the border region and is manifest as either a granular or laminated layer. This endexine appears to be continued under the apertures. *Restio filiformis* (Plate 5.5) has a graminoid aperture, with granules being present in the aperture and an annulus which is raised into an irregular ring. The tectum is not modified, while the foot layer is slightly thickened. In most specimens, granules are found around the edge of the aperture, lying on the endexine. *Ischyrolepis sieberi* is similar to *R. filiformis*, but the graminoid aperture is without an annulus. The endexine occurs in the border region and is manifested as a granular layer with tectal projections.

iv. Amaranthaceae : *Amaranthus thunbergii* Moq. (Plate 5.6) The pollen grains of this family have been studied by Wodehouse (1935), Erdtman (1943) and Van Zinderen Bakker and Coetzee (1959). These grains are cribellate and spheroidal, but sometimes ellipsoidal and vary in size from 12 to 35µm. These polypantoporate grains have 12 to 60 pores (foramina), which are circular and 1 to 2µm in diameter. The endexine has the same granular to sparsely verrucate sculpturing as the rest of the exine and is occasionally flecked with granules which aggregate towards the centre. The exine is 1 to 5µm thick and granulate.

The pollen grains of *A. thunbergii* are spheroidal, cribellate and range in size from 22 to 28μm. The pores are numerous (40 to 60), circular to slightly oval and 1.1μm in diameter, with an operculum having 4 to 16 distinct granules. The exine is 1μm thick and is granulate to sparsely verrucate.

v. **Caryophyllaceae** : *Dianthus albens* Ait. (Plate 5.7).
The pollen of this family is described by Erdtman (1943) and Van Zinderen Bakker (1956). The cribellate grains are similar to Chenopodiaceae but according to Van Zinderen Bakker (1956), "Chenopodiaceae is smaller, has similar foramina and a thinner exine" (p.78). These nearly spheroidal grains are psilate-scabrate to micro-echinate. The grains are polypantoporate, with each pore having a differentiated area around it, in which either sexine or nexine is thinner than the rest of the mesoporium. The columellae are coarse and the tectum is perforated with minute echinae between the perforations. The exine is up to 2.5μm thick, the nexine is a thin layer of less than 1um thick and the sexine is scrobiculate to reticulate or bearing a layer of bacula which may be covered by a tegillum. The pores, which may be as dense as 40 per grain, are circular with well-defined circular edges.

The grains of *Dianthus albens* range in size from 35 to 50μm in diameter and have 15 pores (Plate 5.7). The pores are 10 to 11μm in diameter and 21 to 27μm apart. The opercula have irregular shapes (±7μm across), with a number of fused lumps. The exine is 3μm thick, whereas the nexine is less than 1μm and the sexine is scrobiculate, with pits of 0.5μm. The fused nature of the operculum is visible in Plate 5.7B.

vi. **Chenopodiaceae** : *Chenopodium ambrosioides* L.
(Plate 5.8).
This family has been briefly described by Van Zinderen Bakker (1956). Although the pollen grains vary, a general

description of their morphology is given. These cribellate grains are spherical and small (13 to 43µm in diameter). Between 8 and 50 circular to slightly irregular foramina are present (1-4.3µm in diameter). Colpi are never present and most species are clearly baculate to granular. The exine is thin (1.4-3µm), with the nexine being much thinner than the tegillate sexine.

The grains of *Chenopodium ambrosioides* are cribellate, spherical, to lightly ellipsoidal and between 19 and 34µm in diameter (Plate 5.8). There are 60 to 70 circular to elliptical foramina. The central membrane with a central fleck of the operculum is hardly visible. The foramina are small (1.0-1.4µm) and regularly arranged. The thin exine (1.9-2.1µm) overlies a thinner nexine (0.3µm). The sexine is baculate to densely and minutely granulate.

vii. Ericaceae : *Erica acuta* Andr. (Plate 5.9).
The pollen grains of *Erica acuta* are in tetrads of tetrahedral to spheroidal shape and vary in size (± 22µm in diameter). The whole grain ranges in size from 30 to 45µm. Each grain is trizonocolporate, with three well-defined narrow furrows or colpi. The thick-walled exine (1.5µm) has a well-defined granular to verrucate uneven ornamentation. The sexine is thinner and is psilate.

viii. Fabaceae : *Aspalathus spinosa* L. subsp.*spinosa* (Plate 5.10).
The pollen morphology is documented by Van Zinderen Bakker and Coetzee (1959), Erdtman (1943) and an intensive study has been done on Indigofereae pollen morphology by Ferguson and Skvarla (1982) and Ferguson and Strachan (1982). The pollen grains of *Aspalathus spinosa* are small to medium-sized, having a polar axis of 25 to 32µm and an equatorial axis of 28 to 30µm (Plate 5.10). They are spheroidal or subprolate and triangular in the equatorial outline. These grains are trizonocolporate with colpi which extend three-quarters of the length of the polar axis. The colpi are

narrow, usually equatorially constricted by protrusions of the mesocolpium, and costate. The margins of the colpi have a complete tectum which is differentiated into the mesocolpium and apocolpium. The pollen grains have a finely reticulated to foveolate ornamentation. The tectum is perforate to microperforate. The exine is 1.4 to 1.8µm thick, with two layers of equal thickness. The colpi and pores are often surrounded by a psilate margo, which is of great diagnostic value.

ix. Proteaceae : *Diastella divaricata* (Berg.) Rourke subsp. *divaricata* (Plate 5.11).

The pollen grains of the South African representatives of this family are thought to be of a uniform type (Van Zinderen Bakker, 1953), but variations in the ornamentation and interapertural surface have been noted by Pocknall and Crosbie (1988). The grains are triporate, oblate and have a more or less triangular ambit, with an iso-polar or plano-convex shape. The sides of the triangular ambit are straight with the angles being rounded. The pores are situated at the angles on the equator on the proximal side. The exine is slightly thicker at the poles, consisting of two layers. The sculpturing varies from psilate, scrobiculate, pitted or reticulate with polygonal meshes.

The pollen grains of *Diastella divaricata* are triporate, oblate, ambit triangular with straight to convex sides (Plate 5.11). Their size ranges from 28 to 35µm (diameter in polar view). The pores are circular to elliptical and situated on the three truncated projections on the corner of the triangular grain. The exine is of even thickness (1.4µm) with a reticulate, polygonal mesh of an irregular shape. The reticulate pattern of the sexine is formed by bronchi which are separated by muri (0.6µm in height). The pores are surrounded by a ring of fine mesh, which forms a distinct interapertural surface.

x. Rhamnaceae : *Phylica gracilis* D.Dietr. (Plate 5.12).
The pollen grains of *Phylica gracilis* are tricolporate and oblate to spheroidal (Plate 5.12). They range in size from 21 to 26µm. The germ pores are conspicuous (0.2-0.7µm in diameter), are lalongate and have an annulus of ±0.2µm. The pores are located in the middle of a well-defined deep furrow or colpus, which extends three-quarters of the length of the grain.

xi. Rubiaceae : *Anthospermum aethiopicum* L. var *aethiopicum* (Plate 5.13).
The pollen grains of *Anthospermum aethiopicum* are isopolar, spheroidal to spheroidal-subprolate, radially symmetrical and primarily trizonocolporate, but occasionally tetrazonocolporate (Plate 5.14). The grains are sometimes longer than they are broad and vary in size from 25 to 35µm. The colpi are short, narrow, slightly sunken, equatorially constricted and often appear as a slit in the exine. The grains usually have three colpi, but occasionally four. The exine (1µm thick) is tectate, finely reticulate to faveolate with supratectal processes. The muri are 0.5µm wide, with lumens which are 0.1µm wide.

xii. Rutaceae : *Agathosma bifida* (Jacq.) Bartl. & Wendl. (Plate 5.14).
The pollen grains of *Agathosma bifida* are trizonocolporate and prolate (LS) to spheroidal (TS), as seen in Plate 5.14. They vary in size, but are usually 30µm in length and ± 15µm in width. The sculpturing is striate to rugulate, becoming micro-reticulate in some instances. The muri form a network and in places the muri and lumina seem to run almost parallel to one another. The striae are strong, often lying parallel to the colpi and grading into a reticulum. Striae are fused at the polar ends. The exine is ± 1.5µm thick. The pori are circular, well-defined and lalongate. The colpi are long, narrow and crack-like and usually have costae around the pores.

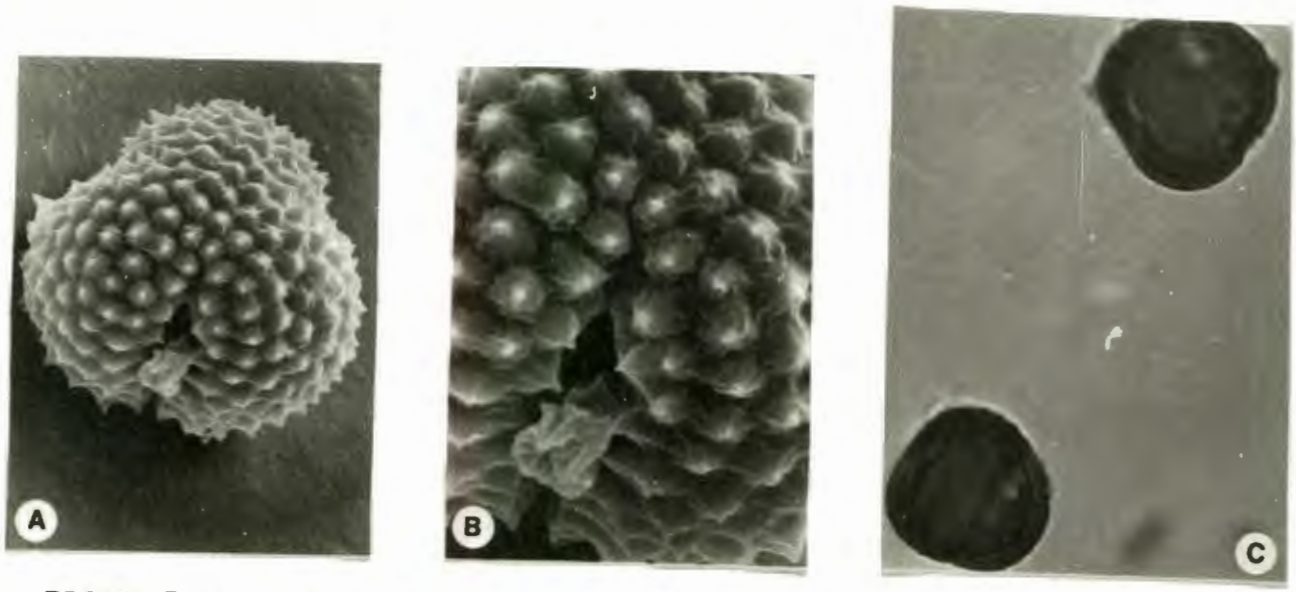

PLATE 5.1A : *Stoebe vulgaris*, SEM, showing the echinae, x2100.
5.1B : *S. vulgaris*, SEM of aperture with smooth inter-apertural surface, x4200.
5.1C : *S. vulgaris*, LM, x1130.

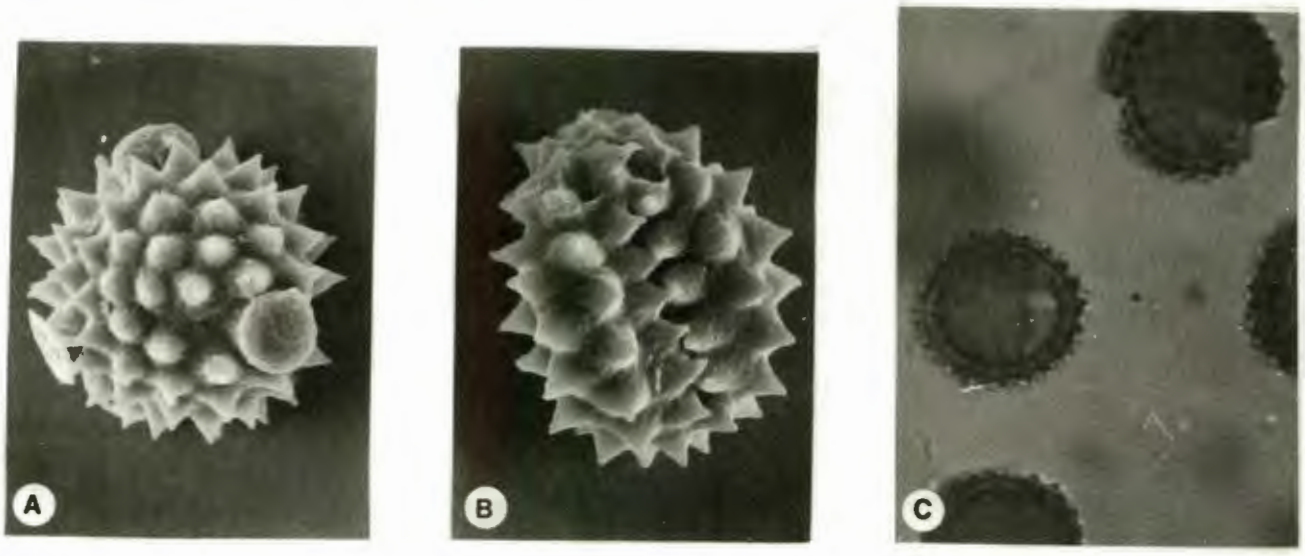

PLATE 5.2A : *Stoebe aethiopica*, SEM showing longer echinae x1800.
5.2B : *S. aethiopica*, longitudinal view showing colpi and spine cavities, x2500.
5.2C : *S. aethiopica*, LM, x1100.

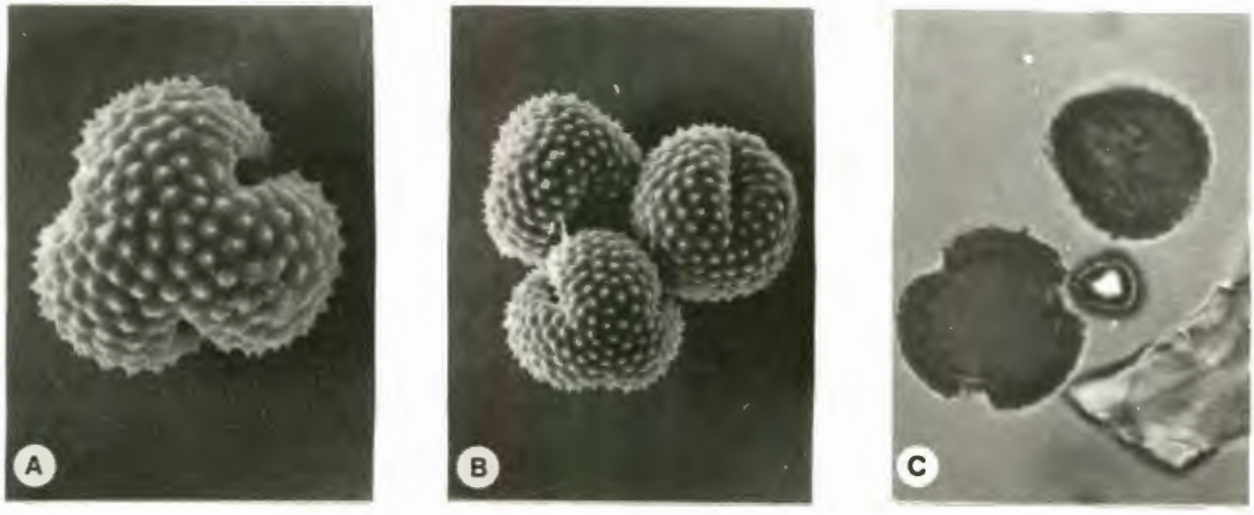

PLATE 5.3A : *Elytropappus rhinocerotis*, SEM of tricolporate grain and colpi, x1800.
5.3B : *E. rhinocerotis*, SEM of longitudinal view showing colpi, x1050.
5.3C : *E. rhinocerotis*, LM, x1200.

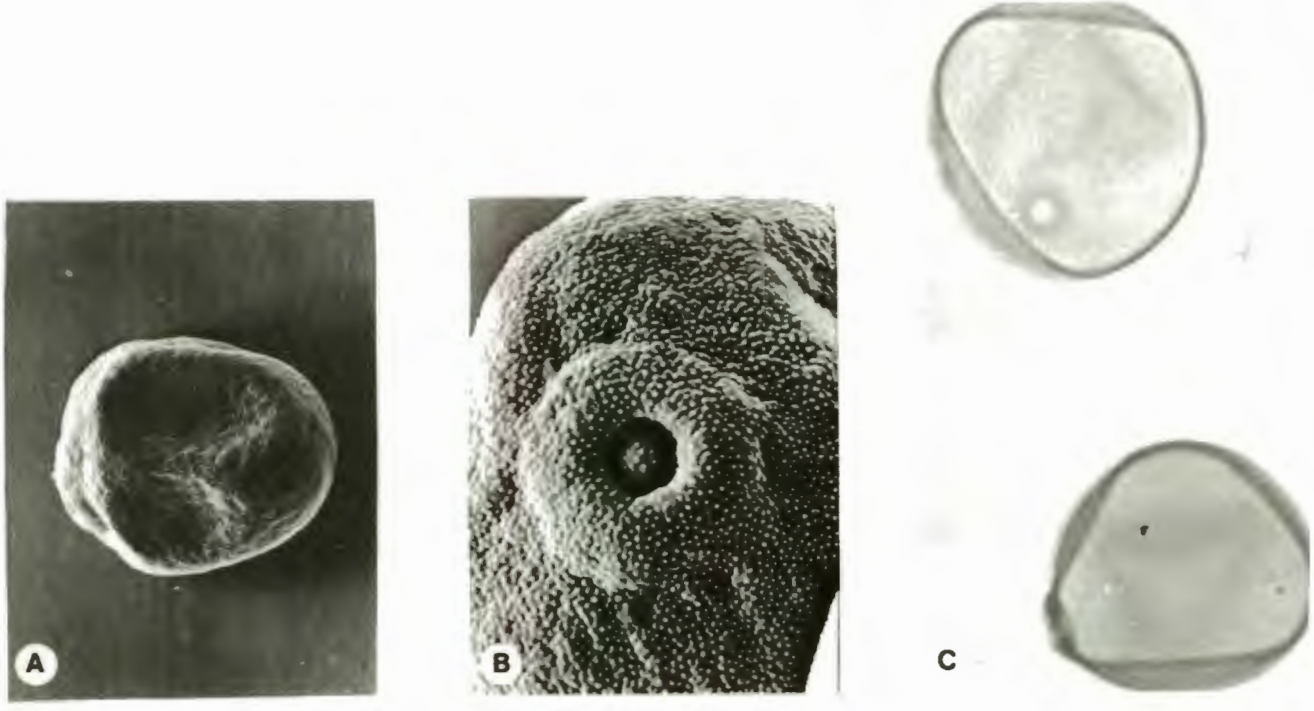

PLATE 5.4A : *Pentameris macrocalycina*, SEM showing single raised pore and ornamentation, x900.
5.4B : *P. macrocalycina*, SEM of pore, annulus and operculum, x2700.
5.4C : *P. macrocalycina*, LM, X1000.

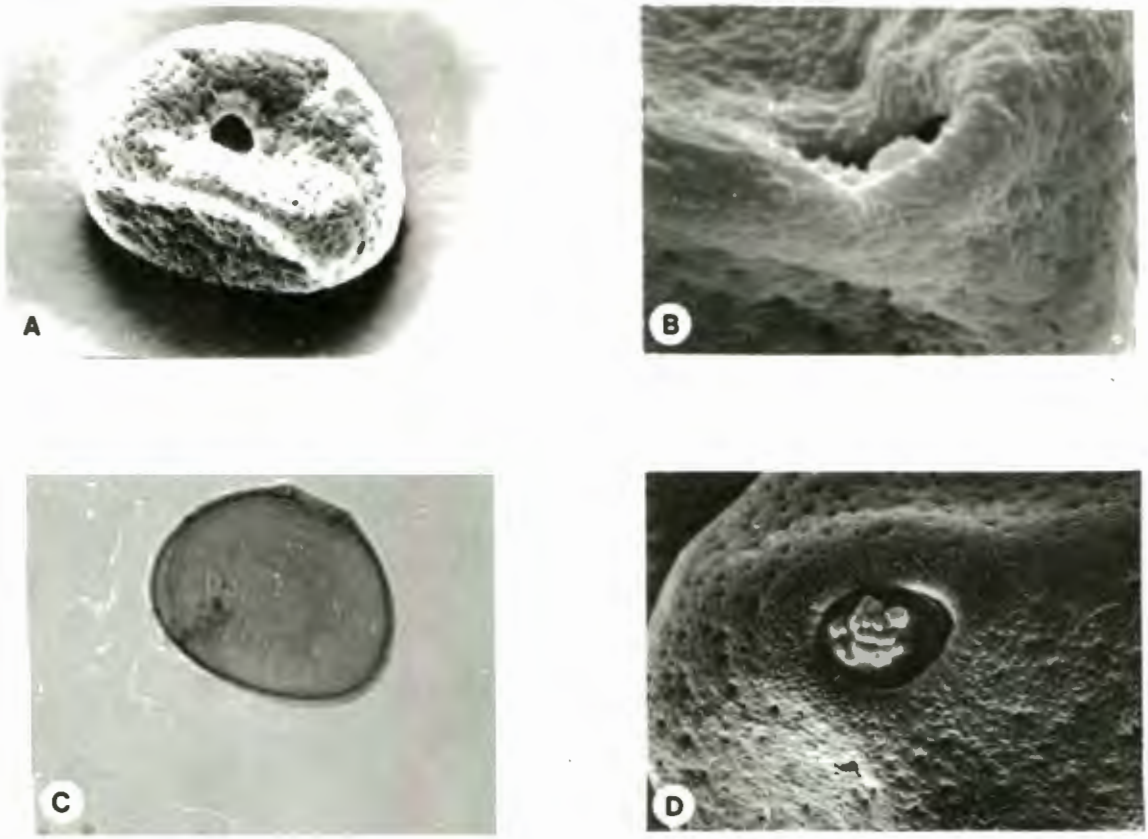

PLATE 5.5A : *Restio filiformis*, SEM showing scrobiculi and aperture, x1050.
5.5B : *R. filiformis*, SEM of aperture, interapertural surface and granules, x4600
5.5C : *R. filiformis*, LM, x700.
5.5D : *Ischyrolepis sieberi*, SEM of aperture and tectal projections on operculum, x2300.

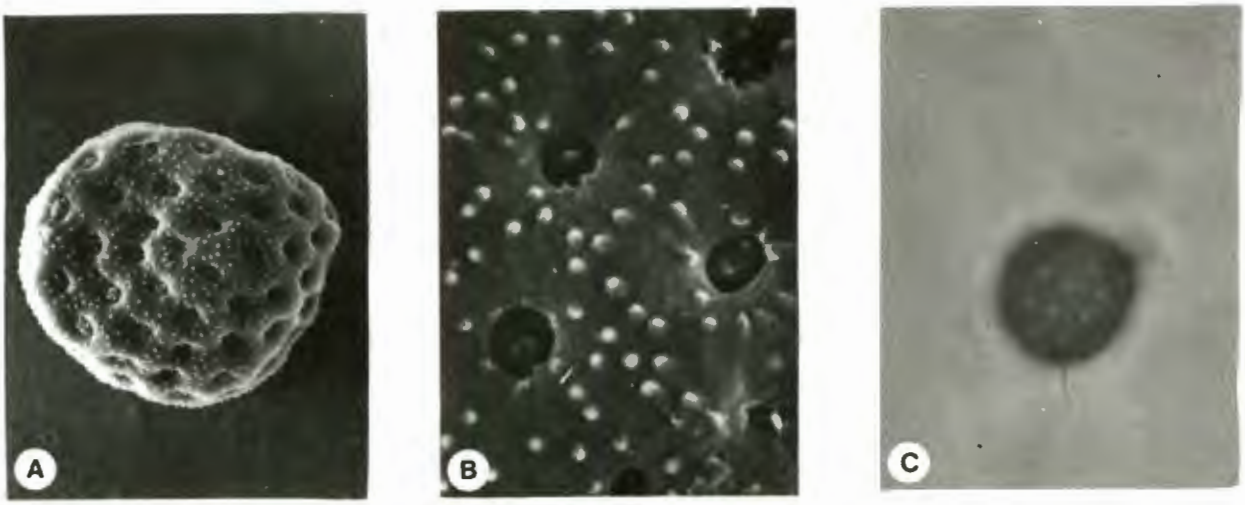

PLATE 5.6A : *Amaranthus thunbergii*, SEM of cribellate grain, x2000.
5.6B : *A. thunbergii*, SEM of pores,operculum and granules, x8500.
5.6C : *A. thunbergii*, LM, x840.

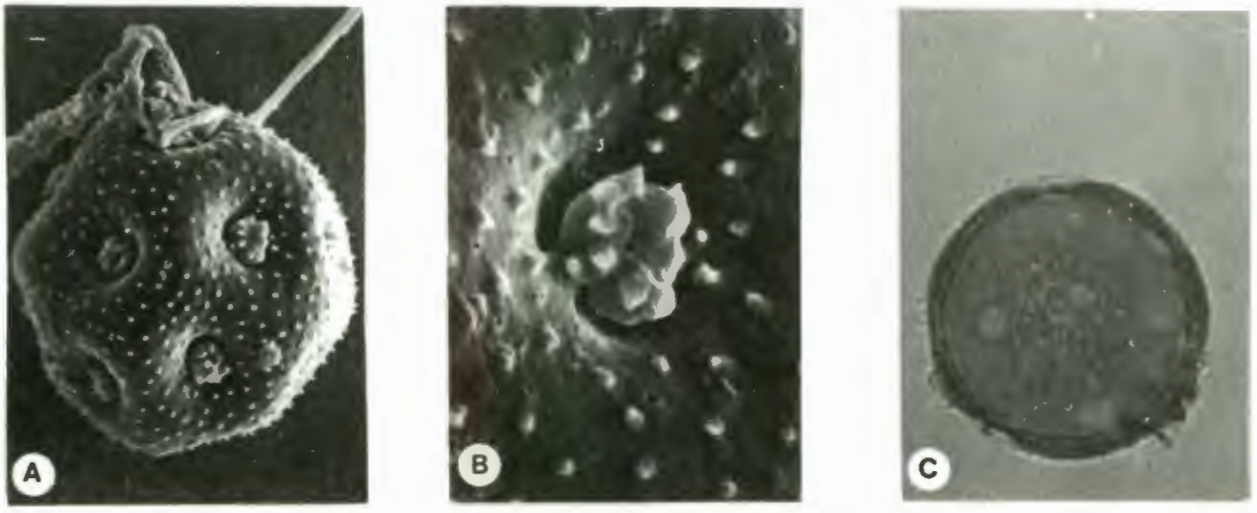

PLATE 5.7A : *Dianthus albens*, SEM, x1300.
5.7B : *D. albens*, SEM of pore and operculum, x 4600.
5.7C : *D. albens*, LM, x1050.

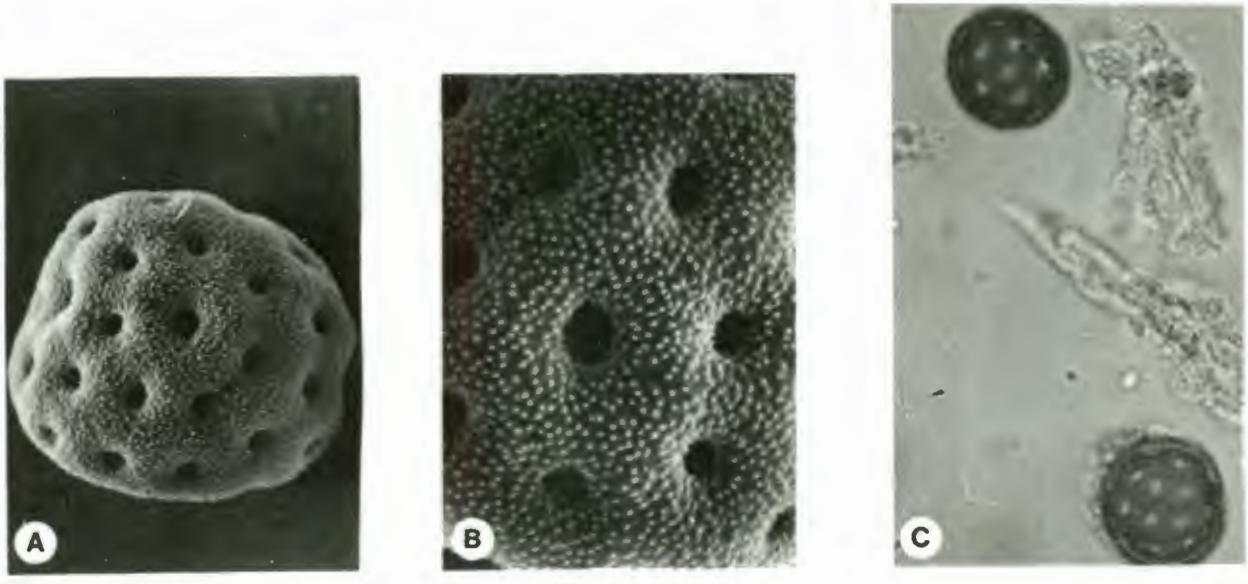

PLATE 5.8A : *Chenopodium ambrosioides*, SEM showing granular exine, x2850.
5.8B : *C. ambrosioides*, SEM of simple foramina, x 5600.
5.8C : *C. ambrosioides*, LM, x1120.

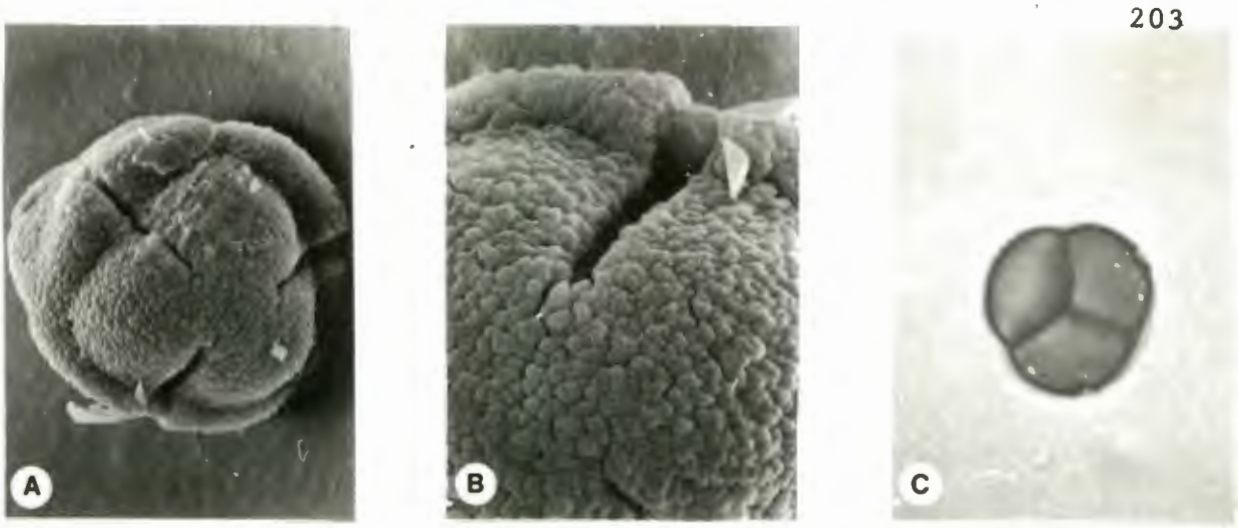

PLATE 5.9A : *Erica acuta*, SEM, x1700.
5.9B : *E. acuta*, SEM of well-defined colpi, x4200.
5.9C : *E. acuta*, LM, x850.

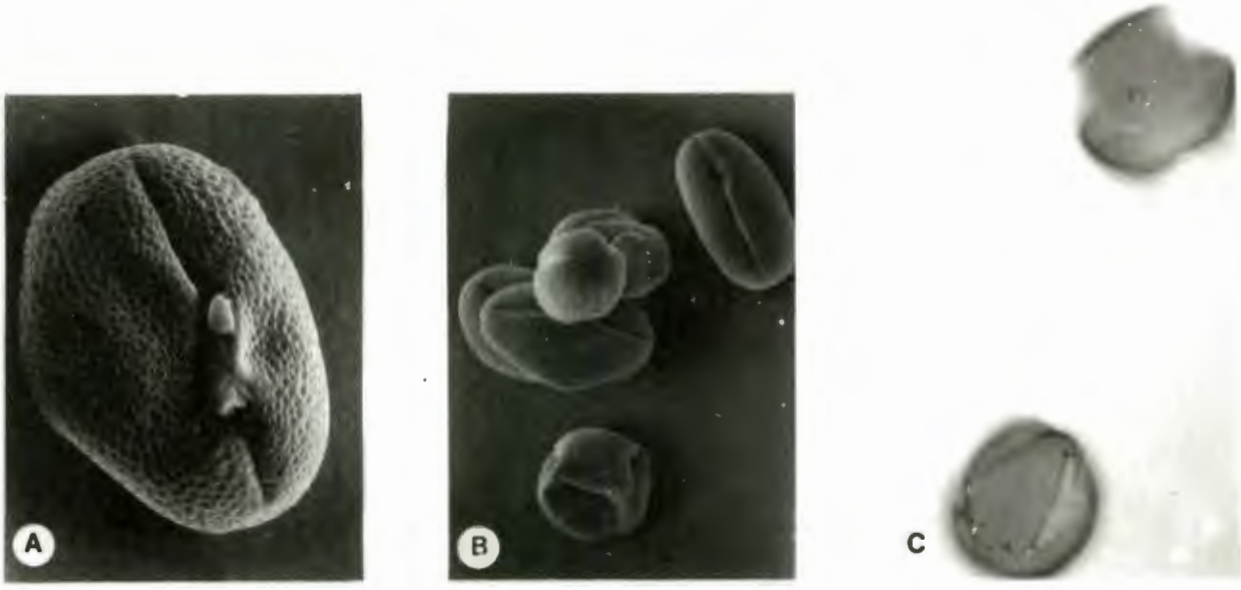

PLATE 5.10A : *Aspalathus spinosa*, SEM of colpi and psilate margo, x1700.
5.10B : *A. spinosa*, SEM showing longitudinal and equatorial view, x650.
5.10C : *A. spinosa*, LM, X810.

PLATE 5.11A : *Diastella divaricata*, SEM showing reticulate ornamentation and pores, x1900.
5.11B : *D. divaricata*, LM, x780.

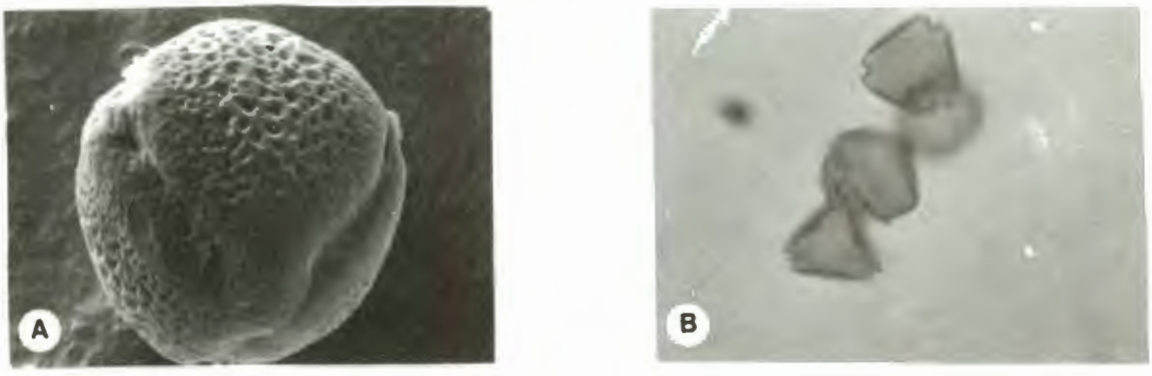

PLATE 5.12A : *Phylica gracilis*, SEM of colpus and exine, x2200
5.12B : *P. gracilis*, LM, x630.

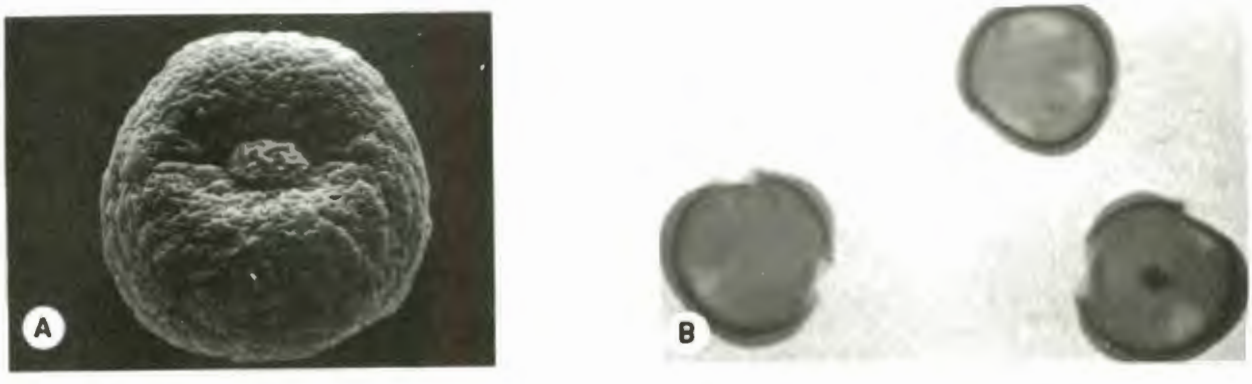

PLATE 5.13A : *Anthospermum aethiopicum*, SEM showing colpus, apertural operculum and faveolate exine, x1800.
5.13B : *A. aethiopicum*, LM, x1000.

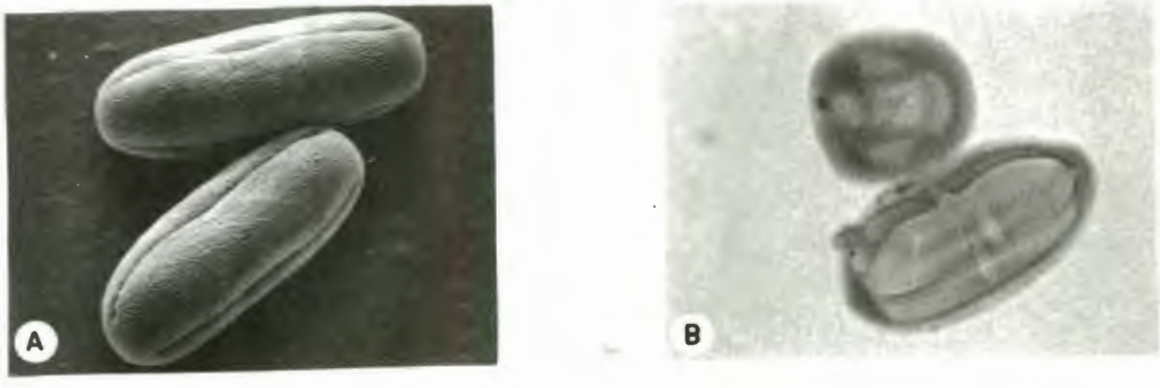

PLATE 5.14A : *Agathosma bifida*, SEM showing colpi and rugulate-striate sculpturing, x1250.
5.14B : *A. bifida*, LM, X1000.

CHAPTER 6

LATE QUATERNARY VEGETATION HISTORY OF THE KAROO UPLANDS

6.1 INTRODUCTION.

Detailed palynological investigations have been conducted at all of the study sites. The upland mountainous sites are some distance apart and extend from the western margin to the eastern extreme of the Karoo. Local vegetation reconstructions could only be undertaken at each of these upland areas within the Karoo. The vegetation history for the Karoo Biome may then, perhaps, be extrapolated if additional archaeological, environmental and climatic evidence is obtained from the arid lowland plateaux between these mountainous areas. Bearing in mind the problems concerning the application of palynology in semi-arid environments of southern Africa (Chapter 4), the pollen diagrams are interpreted and the vegetation history of the four regions is reconstructed.

To enhance interpretation of the fossil pollen data, "indicator values" of pollen from other sites within southern Africa are used (Birks and Birks, 1980). Taxa indicative of particular environmental conditions are identified and the associated trends examined. The indicator-species approach to community reconstruction involves the extrapolation backwards in time, of known phyto-sociological and ecological preferences of individual taxa. The complexity of the flora makes generic identification of pollen difficult and thus many forms have only been identified to family level. In many cases this is not accurate enough, but in southern Africa few palynological studies have progressed to identifying taxa beyond the family level. Most plant families, particularly

Diagrammed taxa	Content	Ecological significance
Cyperaceae	Many species	Important in marshy places forming
	Epischoenus spp*	swards, predominant in later stages
	Ficinia acuminator*	of evolution of hydrosere.
	Cyperus rupestris+	Most important locally produced
	Scirpus inanis+	element.
	Ficinia elongata+	
Restionaceae*	Cannomois virgata	Adundant in moist heath environments
	Perplexis, Elegia.	and Restioid Fynbos.
	Restio filiformis	Adundant in drier heath environments
	Restio curviramis	and Asteraceous Fynbos.
Ranunculaceae	Ranunculus multifidus	Abundant in moist, disturbed areas.
Liliaceae	Kniphofia rooperi	Geophytes of marshy environments.
	Trachyandra jacquiniana*	
Labiatae	Mentha aquatica	Aromatic herb of most vlei areas.
Oxalidaceae	Oxalis	Small herb of moist, disturbed areas.
Poaceae	Themeda triandra +	Fertile upper plateau of Winterberg,
	Merxmuellera stricta +	Sneeuberg & Nuweveldberg.
	M. disticha +	
	Aristida +	Lower altitudes of Karoo hills.
	Ehrhartha *	Marshy heathlands.
	Pentaschistis *	
Aizoaceae	Tetragonia	Small succulents of xeric environments,
	Ruschia	characteristic of Karoo.
Asteraceae	High spines	Characteristic of dry heath & Karoo plains.
	Stoebe vulgaris +	Disturbed dry, mountain grasslands.
	Stoebe aethiopica*	Invading mountain fynbos due to burning.
	S. plumosa*	High altitude shrubs, associated with
	S. alopecuroides *	cold conditions.
	Elytropappus adpressus*	Shrubs of dry mountain fynbos.
	E. rhinocerotis +	Shrubs of dry, disturbed upland areas.
	Pentzia incana+	Unpalatable Karoo-bush of overgrazed areas.
Malvaceae	Hibiscus aridis	Small shrubs of dry disturbed grassland.
Plantaginaceae	Plantago lanceolata	Herb of disturbed dry grassland.
Sterculiaceae	Hermannia spinosa	Dwarf shrubs of karroid grassland.
	H. linifolia, H. cuneifolia	
Scrophulariaceae	Walafrida, Limosella,	Small undershrubs and herbs of mountain
	Hebenstreitia, Selago	grasslands.
Acanthaceae	Monechma	Shrubs of dry Karoo plains and bushveld.
Bignoniaceae	Rhigozum obovatum	Shrubs of dry Karoo plains, prolific flowerer.
Chenopodiaceae	Chenopodium ambrosioides	Straggling shrubs growing in dry
	Atriplex	river beds in Karoo & in salt-marshes.

Diagrammed taxa	Content	Ecological significance.
Caryophyllaceae	Dianthus	Moist fertile heathlands or grasslands.
Crassulaceae	Crassula	Dry rocky habitats.
	Cotyledon orbiculata	Succulent Karoo & dry rocky areas.
Euphorbiaceae	Euphorbia mauritanica	Succulent shrubs of dry, rocky areas.
	Euphorbia	
Ericaceae	Erica	Variety of heathland habitats, usually moist, upper altitudes.
Tiliaceae	Grewia occidentalis	Woody scrambler, bush-clumps or moist areas.
Thymelaeaceae	Passerina rigida	Shrubs growing in a variety of localities,
	Passerina montana	especially open heath.
	Struthiola *	Shrubs of open heath.
Rubiaceae	Anthospermum	Small shrubs common in heath.
Rhamnaceae	Phylica	Small shrubs of coastal & inland heath.
Rutaceae	Agathosma	Shrubs of moist heath environments.
Bruniaceae *	Berzelia lanuginosa	Shrubs of wet heath areas.
	Brunia	
Fabaceae	Acacia karroo +	Small thorny tree of dry Karoo plains.
Rosaceae	Rubus pinnatus +	Creeping bramble of moist areas, forest margins, disturbed areas.
	Cliffortia ramosissima+	Shrubs of dry or wet heath on Winterberg.
	Cliffortia arborea +	Stunted trees on upper Nuweveldberg plateau.
	C. ruscifolia *	Shrubs of mesic fynbos, common adjacent to seepage areas.
Oleaceae	Olea capensis	Major forest species.
	Olea africana	Shrubs of inland scrub, associated with open bush and stony soil.
Podocarpaceae *	Podocarpus latifolius	Major dry & wet forest trees.
	Podocarpus falcatus	
Celastraceae	Maytenus	Medium to large trees in dry-type montane
	Cassine croceum	forest and scrub.
Proteaceae *	Protea nitida	Large shrubs of open dry heath & scrub.
	Protea laurifolia	Trees of moist kloofs & mountian slopes.
	Leucodendron saligna	Shrubs of drier heath plains.
	Paranomis tomentosus	Shrubs of rocky, colder Sneeuberg plateau.
Cupressaceae *	Widdringtonia cedarbergensis	Trees of rocky upper plateau of Cederberg.

Table 6.1 Pollen taxa of the Karoo and Fynbos pollen diagrams and their ecological significance.

* = taxa restricted to the Mountain Fynbos of the south-western Cape.

+ = taxa restricted to the Karoo.

From Story (1952), Coetzee (1967), Martin (1968), Gledhill (1969), Scott (1982c) & Scholtz (1986).

Asteraceae and Poaceae, which are abundant in the Karoo, include many thousands of species which are adapted to a wide range of conditions. In the central Karoo for example, Asteraceous pollen could indicate both mesic conditions (*Helichrysum* spp) or dry conditions (*Pteronia* and *Chrysocoma* spp). This is a real problem and needs to be considered when interpreting the ecological significance of pollen spectra represented on the family level. Table 6.1 lists some of the taxa from the Karoo and Fynbos pollen diagrams and their generalised ecological implications. The indicator taxa usually identified (Coetzee, 1967; Martin, 1968; Scott, 1982c; Scholtz, 1986) include Poaceae, Restionaceae, Asteraceae, *Elytropappus*, *Stoebe*, Chenopodiaceae, Bruniaceae, Ericaceae and forest taxa.

Poaceae pollen is spherical, uniform in structure and generically indistinguishable using the light microscope and size variations. Van Zinderen Bakker (1953) differentiates between the small wild grass type and the larger cereal types. Throughout the Karoo, Poaceae pollen dominates the pollen spectra and is present in varying frequencies depending on the surrounding vegetation. Due to the problems associated with the generic identification of Poaceae, it is impossible to predict the type of grassland represented in the pollen diagram unless other indicators are present. The prevalence of Restionaceae pollen, in about equal frequencies to Poaceae, indicate fynbos conditions. The prevalence of Poaceae pollen in frequencies of about 30% suggest grasslands, as found on the Winterberg Plateau. Poaceae pollen is usually over-represented in the pollen spectrum as the plant is an abundant pollen producer and is wind dispersed, thus facilitating movement over great distances. The frequency of Poaceae pollen in relation to the frequency of pollen from the Karroid-bushes and shrubs does however, indicate the "grassiness" of the surrounding region.

The prevalence of **Restionaceae** pollen is an important indicator of fynbos or macchia vegetation. Although it seldom dominates the spectrum, it contributes about 20% of the pollen in many fynbos assemblages. Restionaceae pollen, together with the increased abundance or presence of Proteaceae and Ericaceae suggest fynbos. In addition to indicating fynbos conditions, Restionaceae may be used as an indicator of local moisture conditions and vleis. Restionaceae is found at both ends of the moisture spectrum; in moist Restioid Fynbos (Campbell, 1986a) and in drier Asteraceous Fynbos. To determine the type of fynbos it indicates one has to examine the associated taxa. Restionaceae which is associated with high frequencies of Bruniaceae and Cyperaceae indicate a moist Restioid Fynbos, whereas Restionaceae which is associated with high frequencies of Asteraceae and Proteaceae suggests a drier fynbos.

Asteraceae. This is a large, ecologically diverse group and its members produce a number of distinctive pollen types. The family is an important component of the Karroid vegetation, but is also represented in varying frequencies in pollen spectra from the eastern grasslands and western fynbos. Asteraceae pollen is a major contributor in the spectra from the central and eastern Karoo, but is present in lower frequencies (40%) in the fynbos spectra. Although many of these flowers are insect-pollinated and produce fewer pollen grains than Poaceae, they are well-dispersed and therefore well represented (Hamilton, 1972). According to Coetzee (1967), high percentages of Chenopodiaceae and less than 50% Asteraceae pollen is indicative of a dry Karroid vegetation. Frequencies determined from absolute pollen counts on the Nuweveldberg indicate that the contribution by Asteraceae pollen may drop to 30% and still be indicative of a Karroid vegetation. This family is not specific to one vegetation assemblage and therefore, one has to examine the frequencies of associated taxa in order to determine its ecological significance.

Stoebe-type pollen occurs in the Winterberg, Nuweveldberg and Cederberg spectra and is predominantly that of *Stoebe vulgaris*, which is abundant in all these areas in the present vegetation. Due to the importance of *Stoebe* and *Elytropappus* as environmental indicators, detailed examinations using SEM and LM were undertaken to distinguish these genera. In addition, a number of *Stoebe* spp were examined, including *S. vulgaris, S. leucocephala* and *S. plumosa* (section 5.6.1.i). Most taxa from this genus are recorded from the coastal areas of the Cape Province. One example is *S. vulgaris* which is recorded in the upper plateaux, at high altitudes and low temperatures. At present it is taken to indicate disturbance and poorly managed veld (Meadows and Meadows, 1988), as indeed is the case on the Winterberg and Cederberg areas. *Stoebe plumosa*, which is recorded at high altitudes in the Cederberg, is also recorded by Coetzee (1967) at high altitudes on the Stormberg and Drakensberg and is indicative of cool conditions.

Elytropappus rhinocerotis, another member of Asteraceae, is an important indicator-species which is common in the overgrazed or disturbed areas of the Karoo and a dominant component of the Renosterveld in the south-western Cape (Taylor, 1978; Boucher, 1980; Cowling *et al.*, 1986). *Elytropappus* is often seen in association with *Stoebe vulgaris* on the overgrazed plateau regions of the Sneeuberg and Nuweveldberg, but is rarely found in the moister Winterberg area, except in severely over-grazed areas. In the Mountain Fynbos areas, the predominance of *Elytropappus* is an indicator of disturbance and in the Coastal Renosterveld it is the dominant undesirable shrub (du Toit and du Toit, 1938). *Elytropappus* is abundant in overgrazed areas and fires stimulate re-growth (Cowling *et al.*, 1986). The abundance of *Elytropappus rhinocerotis* pollen in the Cederberg is therefore indicative of disturbance and is usually confined to shaley soils. It should be noted that in some cases the same taxa may indicate different

ecological conditions in different localities, particularly a taxon like *Elytropappus*, which is widely distributed.

Chenopodiaceae are typical components of the vegetation of dry regions and saline habitats in South Africa and, therefore, the pollen is used as an indicator of these conditions. These plants have small flowers which produce little pollen, but this is compensated for by the production of many flowers. *Atriplex* and *Chenopodium* are widely distributed in the Karoo, but seldom found in the Fynbos. Coetzee (1967) recorded high Chenopodiaceae values in Aliwal North and infers that they are indicative of dry and warm conditions.

Apart from indicating fynbos, **Ericaceae**, which is also found in isolated areas at high altitudes throughout southern Africa, is indicative of moister conditions. Ericaceae is found throughout the Fynbos Biome and in outlying mountainous areas as far east as the Winterberg and Drakensberg. In these outlying "heath" areas, Ericaceae occurs at altitudes where moisture is augmented by mist or fog and *Ericas* are dominant on the moister, warmer north-western mountain slopes. Most of the taxa are entomophilous and are usually under-represented in the pollen traps, but more abundant in surface samples. In Yorkshire, Peck (1973) found that *Calluna* pollen was poorly dispersed in the atmosphere, which is similar to the findings for the Cape Town area by Hawke (1989).

Within the Karoo, members of **Caryophyllaceae** are restricted to moist fertile areas, whereas in the Mountain Fynbos this taxon is not confined to moist areas although it is observed in these areas. The observation of this pollen in sequences from the Karoo is indicative of moister conditions but, in the Fynbos is only indicative of moister conditions if associated with increased frequencies of Bruniaceae, Cyperaceae or similar indicators of moist conditions.

Bruniaceae is restricted to fynbos and is usually located in or adjacent to moist, boggy areas. This pollen eg. *Berzelia* and *Brunia*, is therefore indicative of wet heath environments.

The indicator-species approach to climatic reconstruction is limited, because it assumes that particular taxa are controlled by only one or a few environmental factors. The alternative approach is to use the whole fossil pollen assemblage and a large number of environmental variables to try to find some correlation between the two. Because of the volume of data, multivariate methods are then required for the analyses. Both approaches are used in this discussion and seem to complement one another. The pollen diagrams and associated results from the multivariate analyses are interpreted for each of the areas and then combined and discussed within a regional context. Published archaeological and other geomorphological evidence from a variety of sources is used to augment the palynological evidence and provide a clearer picture of the vegetation history of the Karoo Biome.

6.2 RECONSTRUCTION OF THE WINTERBERG VEGETATION HISTORY.

6.2.1 CONTEMPORARY VEGETATION-POLLEN RELATIONSHIPS.

An analysis of the contemporary pollen spectra in and around the Winterberg area was undertaken by Meadows and Meadows (1988) in a manner similar to that conducted for the Nuweveldberg and Cederberg areas. The pollen traps were erected in each of the vegetation assemblages viz. thornveld, Afromontane forest, grass-heath, pine plantation and vleis. The results of pollen analysis of the eight pollen traps are presented in Figure 6.1 and are used to facilitate interpretation of the fossil pollen analysis. The pollen traps from Dunedin vlei (W7, W13, W14) show that the environments yield pollen spectra which are a good

reflection of the contemporary vegetation patterns in the catchment area. The spectra are dominated by grasses and sedges, as indeed are the local and surrounding communities. Despite the slightly under-represented arboreal component, the general impression gained from this contemporary pollen spectrum is that the pollen rain from the vleis present an accurate reflection of the Winterberg vegetation pattern as a whole. Using this representative contemporary pollen data, the Ellerslie pollen diagram is interpreted and the environmental implications thereof, discussed.

6.2.2 VEGETATION HISTORY INFERRED FROM FOSSIL POLLEN DATA.

The core from Ellerslie Vlei (Figure 5.1) extends to 160cm, which is substantially shallower than those extracted at Dunedin and Salisbury vleis by Meadows and Meadows (1988). The initiation of organic sedimentation at Ellerslie Vlei at 4 200 BP probably represents a shift to moister conditions with a greater local vegetation cover than had previously prevailed. This suggests that conditions ameliorated somewhat from what had been a more arid period following the initial climatic amelioration about 12 000 years ago. This is indicated by the onset of organic sedimentation at Dunedin at 12 500 $\pm$ 160 BP and Salisbury at 11 800 $\pm$ 120 BP (Meadows and Meadows, 1988). Due to the paucity of radiocarbon dates it is unwise to assume a uniform rate of sedimentation in this core. The crumbly fibrous organic matter is less compacted than the amorphous organic matter and probably accumulated at a faster rate relative to the rest of the core. The substantial pollen fluctuations in the core may, however, correlate with similar occurrences in Dunedin and Salisbury cores and in that way regional changes may be extrapolated.

The mean density of pollen grains within this core is relatively high (11 370 grains per cm^3 organic matter) and is constant throughout the time span investigated. This feature, together with the constant frequency of unknowns,

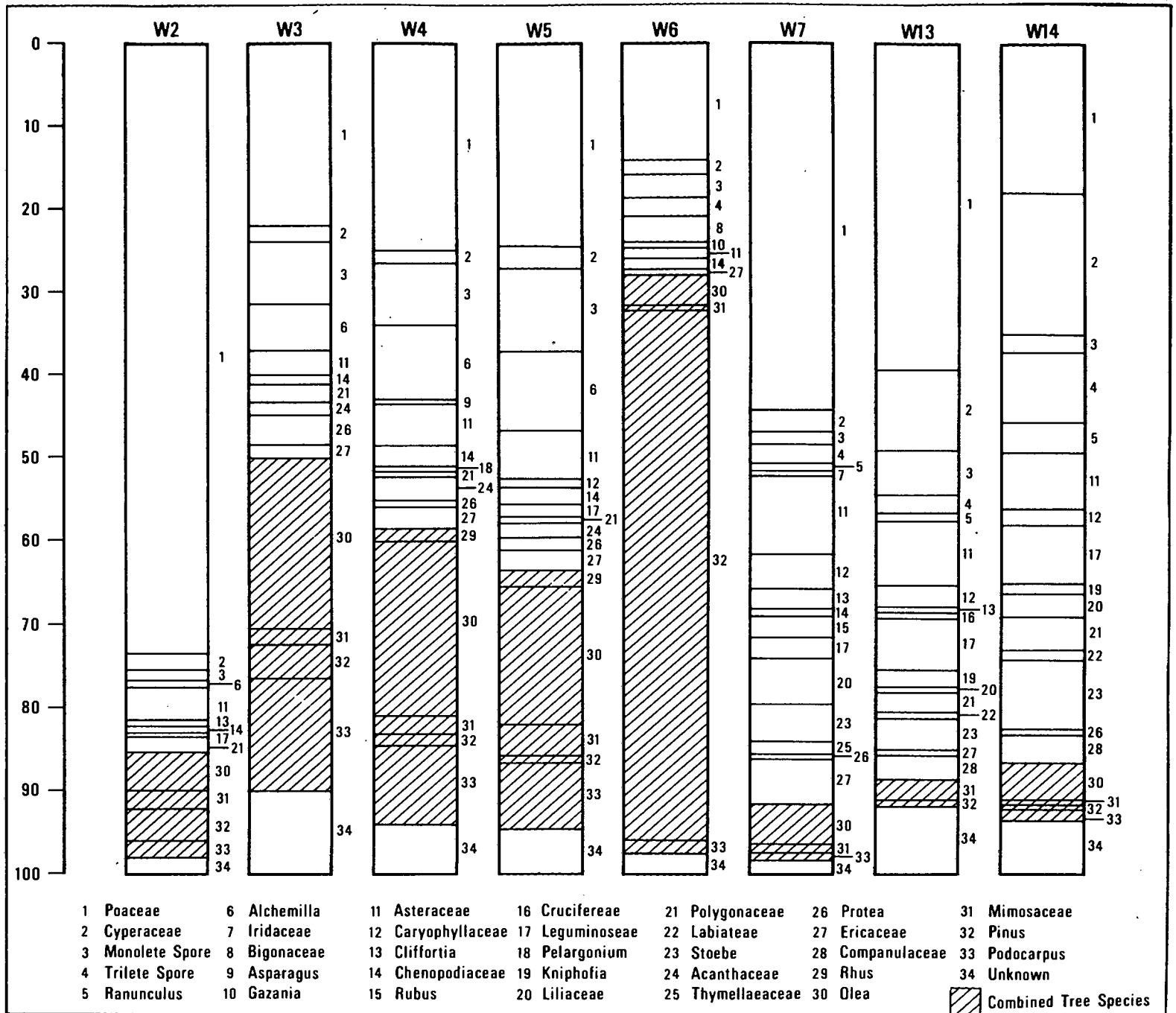

Figure 6.1 The Winterberg pollen trap spectra (From Meadows and Meadows, 1988).

suggests that preservation conditions have not varied substantially with time. The pollen densities are slightly higher in the amorphous organic matter, suggesting slightly better preservation conditions.

Three pollen assemblage zones are identified in the Ellerslie pollen diagram, each having some ecological significance. **Zone Ea**, representing the base of the core and the onset of organic sedimentation is suggestive of a moist vlei environment. Figure 5.1 shows that Asteraceae pollen frequencies are consistently high and then decline, while Poaceae and Acanthaceae frequencies are relatively low and increase. Aizoaceae, Chenopodiaceae and Cruciferae, which are indicators of xeric conditions, are notably absent until the top 5cm of this zone, where there is a small increase in Aizoaceae frequencies. Within the regional environment the indications are therefore of moist open herbaceous communities with Asteraceous shrubs representing an important component. The small but consistent proportion of Afromontane forest elements and the low frequencies of Karroid shrubs further supports the idea of a moist period prevailing at this time. This zone appears to be similar to that of zone Sc1 from Salisbury Vlei (Meadows and Meadows, 1988), where Afromontane patches expanded and warmer, moister conditions prevailed. It is difficult to match these zones chronologically, as Salisbury only has a basal date of 11 500 BP. Zone ScI is about half way down the Salisbury deposit (at a depth of 100cm) and could therefore represent an age of about 5 000 BP. With this reasoning, zone Ea from Ellerslie and the upper half of zone ScI from Salisbury may represent a similar time period. At no time does the Afromontane forest element in zone Ea increase to proportions much greater than those shown in the contemporary spectrum, suggesting that at no time during the past 4 200 years has the Afromontane forest community of the Elandsberg expanded much beyond the present-day patches. The suggestion by Meadows and Meadows (1988) that these forest patches have remained largely confined to the south-

facing slopes in patches or "kloofs" during the Holocene is substantiated here.

Summer occupation of rock shelters in the Winterberg by hunter-gatherer communities is dated from about 4 000 BP (Hall, 1986, 1988). After 1 500 BP, the pastoralists exploited the area for seasonal summer grazing. The impact of these early people on the vegetation of the Winterberg is thought to be relatively insignificant in comparison with that of the early Settlers (Deacon, 1976).

Zone Eb is characterised by a gradual decrease in Cyperaceae, Liliaceae and Labiatae frequencies, suggesting a decline in local moisture availability. There is however, an increase in the frequencies of the dominant vlei components in the top 30cm of this zone, indicating an increase in moisture availability within the vlei. Within the regional environment there is a slight increase in the frequencies of indicators of drier environmental conditions and "disturbance" at this time viz. *Stoebe*, Chenopodiaceae and Cruciferae appear for the first time and the intermittent trace of Aizoaceae in the lower zone becomes more prominent. There are signs of drier conditions within zone Eb, where xeric elements (*eg. Elytropappus*, Thymelaeaceae) are more prominent than in zone Ea. The presence of Thymelaeaceae, Ericaceae and Aizoaceae indicates a dry, cool grass-heath. The abundance of *Elytropappus*, which is most common in disturbed communities and Renosterveld, indicates conditions somewhat drier than the contemporary Winterberg area. A suitable modern analogue for this community is probably that at the tops of the drier Karoo mountains, such as the Sneeuberg and Nuweveldberg. The difference would be that *Themeda triandra* would probably occur on the Winterberg and not Merxmuellera, which presently occurs in the central Karoo. Within the uppermost few cm of zone Eb, conditions appear to have fluctuated and ameliorated. Small increases in Asteraceae, *Maytenus* and Oleaceae frequencies suggest slightly more mesic, moister

conditions than the past, which would account for the slight increase in *Olea* and *Maytenus*.

The uppermost **zone Ec**, which represents a similar period as zones Dd and Sd in Dunedin and Salisbury respectively, probably represents the last few hundred years of sedimentation. It shows signs of disturbance and agricultural activity in the area, a consequence of the arrival of European farming techniques. The relatively high frequencies of *Stoebe, Elytropappus*, Acanthaceae and Pinaceae indicates disturbance towards the top of the pollen diagram, which may be due to recent human activity and veld mismanagement. The increases in *Stoebe, Elytropappus* and Plantaginaceae pollen are particularly interesting, as these taxa are presently taken to indicate disturbance and poorly managed veld (Meadows and Meadows, 1988). A further sign of human activity is the introduction of *Pinus* pollen, arising from the plantations which have been established on the Winterberg during the past 150 years.

A comparison of absolute pollen counts used for the Ellerslie pollen diagram and relative counts used by Meadows and Meadows (1988) for Dunedin and Salisbury pollen diagrams has been made. It shows that the absolute pollen diagram has a greater variety of taxa and that changes in one of the main pollen contributors ie. Poaceae, does not cause an associated change in the other taxa. Within the relative pollen diagrams, Poaceae and Cyperaceae appear to be more abundant and suppress all other taxa, particularly Asteraceae and Fabaceae, which are important components of the Ellerslie pollen spectrum. Absolute pollen counts therefore seem to be more representative of the vegetation than relative counts, and have the added advantage of pollen influx data.

The overall percentages of the major taxa within the vlei environment do not fluctuate greatly throughout the time span of the pollen diagram, indicating a relatively stable,

moist vlei. Within the regional environment, the occurrence of Asteraceous and Afromontane forest elements and the onset of organic sedimentation at the base of the core, indicates a relatively moist period at about 4 200 BP. A gradual change to a drier environment is indicated by increased *Stoebe, Elytropappus,* Acanthaceae and Bignoniaceae pollen percentages. The increasing frequencies of Poaceae and Afomontane forest elements indicate slightly moister conditions prevailing during the final stages of zone Eb. This is followed by a gradual increase in taxa indicative of disturbance or deterioration of the vegetation rather than a decrease in moisture availability. The signs of human activity are apparent in zone Ec, particularly with regard to the increase in Pinaceae and *Acacia* pollen percentages.

The vegetation changes documented at Ellerslie Vlei over the past 4 200 years seem to agree with those depicted in the upper half of the Dunedin and Salisbury pollen diagrams of Meadows and Meadows (1988). The pollen evidence from Ellerslie does not, however, substantiate Acocks' (1953) idea that the sourveld grasslands are derived from the Afromontane forest. This palynological study shows that the karroid elements have expanded eastwards during the past 500 years and could partly be a result of overgrazing and mismanagement. The upper part of the diagram confirms that these changes were a result of disturbance, but that vegetation fluctuations had occurred prior to this period. It would therefore seem that fluctuations in the macro-climate may be a more important vegetation determinant than European settlers. The agro-pastoralist activities of the settlers have however caused fluctuations of greater magnitude than in the past.

6.3 RECONSTRUCTION OF THE SNEEUBERG VEGETATION HISTORY.

6.3.1 VEGETATION HISTORY INFERRED FROM FOSSIL POLLEN DATA.

The sediments from the gully on the slopes of the Compassberg produce some interesting palynological data in which fluctuations in the surrounding vegetation assemblages are apparent (Figure 5.2). The summary pollen diagram (Figure 6.2) shows the decreasing contribution of Poaceae and corresponding increase in karroid shrubs with time. The herb and swamp elements fluctuate slightly, but suggest a relatively stable swamp environment which has not changed greatly over the past 3 500 years. The heath elements, which include Ericaceae, Thymelaeaceae and Polygalaceae, show a gradual decline from the base of the palaeosol to the present. The arboreal element appears to increase slightly with time, although this may be attributed predominantly to an increase in *Acacia* pollen.

The organic band (35-100cm) contains sufficient pollen to indicate the main vegetation trends. The mean pollen density within this band is relatively low (6 102 grains per cm^3), which is as one might expect, as this alluvium has a low organic content and the present day soils are extremely dry. The density of the pollen grains is marginally higher in the amorphous black organic matter than in the fibrous organic matter, which indicates more suitable preservation conditions in the former. The pollen densities and percentages of unidentifiables within the sandy soils below the organic band are considerably lower than that of the organic band and this is attributed to the poor preservation conditions in these dry aerobic soils.

The base of the palaeosol is dated at 3 590 BP. Bousman *et al.* (1988) describe valley fills in the Blydefontein Basin, some 75km northeast of this site. The valley-in-valley configuration at Blydefontein has been formed by an incision into a series of valley fills, in which sediments up to 8m thick have accumulated during the late Quaternary. One of

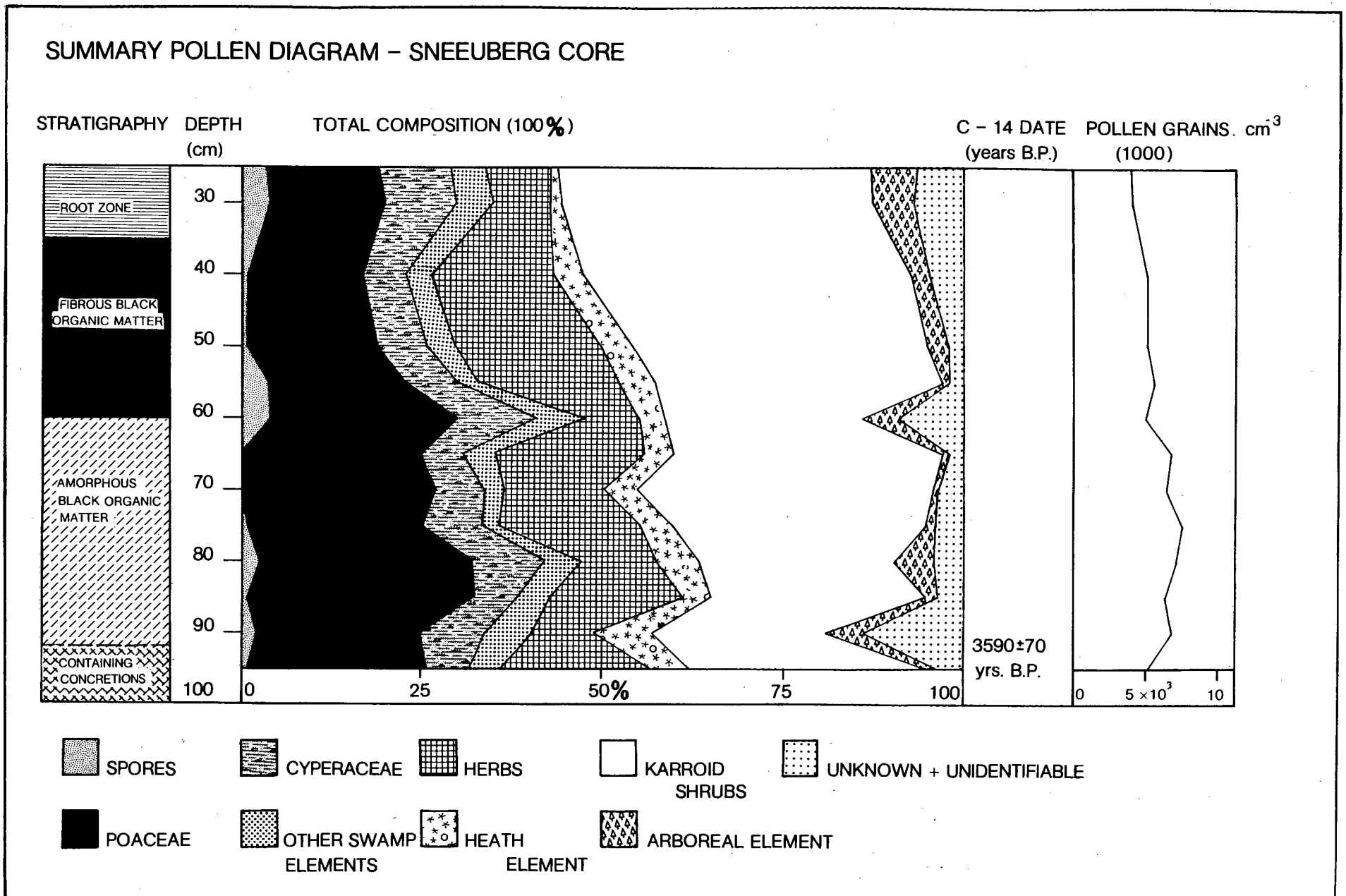

Figure 6.2 Summary pollen diagram from Compassberg Vlei, Sneeuberg Range.

the palaeosols at Blydefontein has been dated at 3 290 ± 60 BP, which is remarkably similar to the age of the Compassberg deposit. Bousman *et al.* (1988) argue that palaeosol formation in this environmental context represents in the order of a few hundred years. Although no date for the upper horizon of the Compassberg gully is available, it may be assumed that the vegetation revealed by the palaeosol represents a few hundred years post-3 500 BP (Meadows and Sugden, 1988). The interpretation of these repeated cut-and-fill cycles suggests that accelerated erosion commenced each cycle. This represents drier conditions with greater seasonality of precipitation and a more unstable hydrological regime under the influence of reduced vegetation cover. During the drier phase, removal of sediment occurs ie. "cut" rather than "fill" phase (Meadows and Sugden, 1988). The organic horizon of the Compassberg palaeosol therefore represents the terminal phase of a wetter period immediately prior to downcutting brought about by a return to more xeric conditions.

Bousman *et al.* (1988) have noted that the local sedimentary systems are hydrologically sensitive and, especially in the headwater vleis such as Compassberg, may respond to subtle shifts in the hydrological characteristics of the basin in terms of precipitation inputs, vegetation cover and runoff. It has been inferred that these cycles of donga erosion, which occurred after about 7 800 BP at Blydefontein and after about 3 500 BP at Compassberg provide evidence for repeated donga erosion in southern Africa long before the advent of agriculturalists, either by Khoisan or European origin. This erosion cycle has, however, been aggravated by local overgrazing in the present century (Novellie, 1988). That this period, the Holocene, was characterised by stable climatic conditions is a misconception (Partridge, 1988), which is contradicted by this research in the central Karoo.

The low concentrations of Asteraceae pollen below 200cm, together with the peak in Cyperaceae and Poaceae pollen at

205cm are indicative of conditions somewhat moister than today prevailing in the catchment immediately prior to 3 500 BP. At the base of the palaeosol, the acceleration of organic sedimentation, together with the higher frequencies of Oleaceae and Ebenaceae pollen suggest conditions somewhat moister than those indicated by the overlying sediments. The pollen frequencies at the base of the palaeosol indicate conditions similar to the Karroid Merxmuellera Mountainveld found on the Compassberg today. Throughout the period of palaeosol development (post-3 500 BP), the local vlei environment remains relatively stable. Within the regional environment the frequencies of Asteraceae, *Elytropappus*, Acanthaceae and Bignoniaceae increase, whereas frequencies of Ebenaceae, Ericaceae, Polygalaceae, Tiliaceae, Thymelaeaceae and Oleaceae all decline. Ericaceae, which is more sensitive to moisture and temperature fluctuations than the karroid shrubs appears to decline in association with the increase in taxa indicative of drier conditions. The gradual increase in *Elytropappus*, Asteraceae and Acanthaceae pollen frequencies indicate increasing aridity of the environment and encroachment of what Acocks (1953) refers to as the "False Karoo". Figure 6.2 indicates a slight increase in the arboreal element with time, which may be attributed to the invasion of *Acacia karroo* into the area during this period. The general impression gained from the pollen diagram is that of a consistent decrease in effective moisture from the base of the palaeosol, at 3 590 BP, onwards. The gradual decrease in pure Merxmuellera Mountainveld and increase in karroid shrubs is apparent. The slow reduction in grass cover may be attributed to a variety of factors, including both environmental and anthropogenic changes.

Palynological evidence from Blydefontein and Hughdale (Bousman *et al.*, 1989) indicate that prior to 7 790 BP the vegetation was shrubby, with high frequencies of Asteraceae and became progressively more grassy after 3 290 BP. Since 1 360 BP the grass cover seems to have declined once more

(Bousman *et al.*, 1989). The interpretation of the Compassberg deposit therefore seems to be consistent with the pollen analyses from the Blydefontein deposits in which gradual drying of the floodplain pool is indicated upwards through the organic horizons (Bousman *et al.*, 1989). The hiatus of evidence for occupation of sites on the Sneeuberg plateau and interior prior to 4 000 BP (T. Hart, pers. commun., 1988) further substantiates the idea that drier conditions preceded the moister phase of c.4 000 BP. Since this time, the climate seems to have fluctuated; indications are that it became progressively drier during historical times.

The reduction in grass cover and encroachment of the False Karoo (Acocks, 1953) appears to have started prior to the introduction of European farming techniques, but has been aggravated by sedentary farming practices. According to Sampson (1985a) the destruction of the Karoo veld cover by San hunter-gatherers and pastoralists was small, but relatively intense around waterholes. The vegetation changes here are thought to be due to fluctuating climatic conditions and the gradual decline in moisture availability. The observation by Sampson (1985b) that visible veld damage is associated with surface traces of prehistoric activity, which was probably less destructive than the present farming activities, serves to highlight the extreme vulnerability of the Karoo ecosystem.

6.4 RECONSTRUCTION OF THE NUWEVELDBERG VEGETATION HISTORY.

6.4.1 CONTEMPORARY VEGETATION-POLLEN RELATIONSHIPS.

Two sampling methods were employed: one relying on the collection of surface samples from a number of different vegetation assemblages and the other involving setting up pollen traps at the same location as the surface samples. Locally produced pollen types fluctuate considerably at different heights above the surface owing to differential pollen production, dispersal and the variation in life forms. Pollen traps have been placed at ground level and another at 1m above the ground to reduce sampling error.

The surface sample spectra (ie. pollen that is likely to accumulate to form the fossil pollen record) do not always reflect the same pattern as depicted by the interpretation of pollen trap spectra. This deviation may be attributed to the different modes of dispersal, pollen production and particularly, preservation conditions. To reduce any bias, both pollen traps and surface samples are used. An analysis of variance was conducted to compare spectra from 1986 to 1987, followed by a comparison of the pollen trap spectra and surface sample spectra.

i. Pollen Trap Spectra.

Most of the pollen traps (88%) were recovered at the end of the 1987 season, which is considerably higher than that of other researchers using identical techniques (Meadows and Meadows, 1988), who had losses of up to 55%. The high recovery rate is attributed to the location of the pollen traps within the Karoo National Park which clearly limits public access to them.

Pollen traps from the vleis are dominated by Poaceae and Cyperaceae pollen, both indicative of the local vegetation. On the whole, at least 35% of the pollen in these traps is from local vlei vegetation. The regional pollen contribution is relatively high, particularly in N11 and may

be attributed to the small size of the vlei. The location of a poplar plantation adjacent to the vlei accounts for the abundance of Salicaceae pollen. As the plantation was not visible on aerial photographs taken in 1945, it seems that it was only recently established. The low percentages of *Populus* and Asteraceae in N10 in comparison to N9 (1m above the ground) is attributed to the sheltering effect of adjacent sedges, which seem to reduce the amount of airborne pollen reaching the basal trap.

Merxmuellera Mountainveld covers the upland plateau adjacent to the vlei. The pollen traps from this area are dominated by Poaceae pollen, with Asteraceae pollen being abundant and possibly over-represented in comparison to the percentage cover of this taxon, particularly in the 1987 spectrum. The spectra from the disturbed Mountainveld are similar to those of the true Mountainveld, but have lower Poaceae frequencies, higher Asteraceae frequencies and a higher species diversity. The increased diversity in the disturbed Mountainveld spectra is attributed to the ecotonal areas which these assemblages occupy. The abundance of Poaceae pollen within the disturbed Mountainveld spectra is due to the occurrence of Merxmuellera grasslands adjacent to, and intermixed with this "Macchia-type" vegetation.

The Upper Karroid vegetation is limited to areas of specific geomorphological and edaphic characteristics. The pollen spectra appear to be similar to those of the disturbed Mountainveld, but have a greater proportion of larger shrubs and the grasses are predominantly *Eragrostis* and *Pentameris*. It is not possible to differentiate grass pollen into generic groups and therefore, this feature is not apparent from the pollen spectrum. The difference between the pollen trap at 1m and that at ground level is obvious, with the trap at ground level (15B) having a much higher Asteraceous content. This could once again suggest a sheltering effect by Asteraceous plants close to the traps and hence, the lower contribution by other surrounding plants. From these

data it can be deduced that the pollen traps at ground level may be selective for plants growing immediately adjacent to the traps. The surface pollen traps are selective for predominantly cryptophytes and hemicryptophytes. Mesembryanthemaceae, which is common for short periods after spring rains has a surprisingly low pollen frequency. This may be attributed to a low pollen production and the prevalence of entomophilous taxa.

Karroid Brokenveld is limited to the Karoo plains and is dominated by "Karoo-bushes", while grasses of the "white-type" occur in the fertile areas. The pollen spectra have notably low Poaceae frequencies and a large proportion of Asteraceae and associated Karroid shrubs, which is a good reflection of the prevailing conditions. Although this vegetation appears to be uniform, the open structure allows dispersion of the pollen and results in a reasonably diverse pollen spectrum - 19 different taxa are represented. An additional factor is that fewer of the Karoo shrubs are entomophilous as compared with the entomophilous macchia or fynbos types.

In general, arboreal taxa are poorly represented in the pollen trap spectra. This is in keeping with the overall vegetation of the area, with the exception of the *Populus* plantation adjacent to the vlei, a cluster of pine trees close to the traps N12 and N13 and a number of introduced trees surrounding Mountainveiw Rest Camp (N14). These trees were introduced to this area by pioneer farmers and the occurrence of their pollen in the fossil spectrum is an indication of when the Dutch Trekboers first occupied this area. The term "Trekboers" is used to describe the European farmers who broke away from the Cape Colony and moved inland to explore new lands, taking with them the sedentary farming practices and a number of alien seeds and plant species.

ii. Surface Sample Spectra.

The pollen grains identified from these samples are poorly preserved. This is attributed to the poor preservation conditions at the surface of these dry Karoo soils. The pollen spectra from surface samples taken from the vlei are dominated by Asteraceae, Poaceae, Cyperaceae, Labiatae and Fabaceae. Pollen from the local vlei environment contributes 35% of the total pollen, with Asteraceae being over-represented within the regional environment. Pollen spectra from Merxmuellera Mountainveld are characterised by the highest Poaceae percentages (35%) of all the surface spectra, but are still under-represented in comparison to the grass-cover in the area. Another complicating factor is that *Themeda triandra* may reproduce by vegetative propagation (personal observation) and, therefore, a pollen spectrum can indicate low Poaceae frequencies when in fact it is abundant in the area. The pollen spectrum obtained from this assemblage is not a good reflection of the distinctive vegetation which occurs in the vicinity.

The pollen spectrum from disturbed Mountainveld is similar to that of Merxmuellera Mountainveld, but has lower Poaceae frequencies and higher percentages of Macchia-type shrubs. The pollen spectrum substantiates the idea that "pure" Merxmuellera Mountainveld no longer occurs, but has been partially invaded by Karroid shrubs. The pollen spectrum from this vegetation assemblage has no distinguishing feature and seems to constitute the ecotonal area between Merxmuellera Mountainveld and the Karroid Brokenveld.

The pollen spectrum from the Upper Karoo highlights the trend of decreasing moisture availability as one descends in altitude onto the middle plateau, with Aizoaceae frequencies increasing and vlei elements decreasing. The pollen spectrum is thus representative of the prevailing vegetation assemblages. The pollen spectrum from the Karoo plains is characterised by the occurrence of taxa indicative of drier environments, eg. Asteraceae, Aizoaceae, Chenopodiaceae and

Bignoniaceae. The vegetation of these plains is sparse and dominated by "Karoo-bushes" which are well represented in the pollen spectrum. The surface sample pollen spectra from the vegetation assemblages present a fair reflection of the vegetation patterns on the Nuweveldberg. The surface samples do, however, appear to under-represent the arboreal pollen component - a problem noted by Meadows and Meadows (1988) and Scott (1982b).

iii. Representivity of Pollen Spectra.

The analysis of variance conducted on data collected in the pollen traps shows that 77% of the taxa do not vary significantly from the 1986 season to the 1987 season. The taxa which vary are predominantly shrubs and bushes of the Macchia-type, including Asteraceae, Tiliaceae, Acanthaceae, Bignoniaceae and Polygonaceae. On the whole, variations are not substantial from year to year.

The variation in pollen data collected from the surface samples is greater, with 43% of the taxa having significant variations from one year to the next. Once again it is the shrubby components that vary - those taxa which usually occur in the semi-arid Karoo environments. The ANOVA identified the taxa which show variation in both data sets (pollen traps and surface samples). These taxa usually occur in disturbed or dry environments, indicating that the 1987 season was probably drier than 1986. The disturbance related to the construction of access roads in the Park may play a role in the variation from 1986 to 1987, but it is probably associated with a decrease in moisture availability. This idea is substantiated by a lower than average annual rainfall (average is 260mm) in the Karoo National Park during 1987. The annual rainfall decreased from 264.2mm in 1986 to 153.1mm in 1987 (Weather Bureau, Pretoria, pers.commun., 1989).

It is apparent that variation in response to environmental conditions does occur from year to year and is greater in

the surface sample data than the pollen trap data. This is probably associated with differential preservation in the topsoil of these dry Karoo soils and an abundance of particular taxa within the local source area. Surface sample spectra appear to be more dynamic than the pollen trap spectra and therefore, replication of these data over a number of years is required to obtain a more accurate picture of the pollen spectra for a particular vegetation assemblage.

iv. Variance between Pollen Trap and Surface Sample Spectra.

One of the assumptions of pollen analysis, is that vegetation communities are a reflection of their environment, in particular climate. Due to the problems associated with inter-specific and intra-specific differences in pollen production, dispersal and preservation, this assumption may only be applied in the broadest sense. A solution to this problem may be in the increase of contemporary pollen studies. The many conflicting ideas on environmental change and climates (Tansley, 1920; Whittaker, 1953; Finegan, 1984; Tyson, 1986) make it apparent that vegetation communities may only approximately relate to the physical environmental conditions. This relationship is difficult to quantify and in some cases the climate may change quite markedly without much impact on community composition. The sensitivity of the vegetation to climatic change is dependent on ecological characteristics and requirements as well as the nature of the climatic change involved.

The significance of this comparison is to establish whether a relationship exists between present day pollen rain, which is recorded in the pollen traps, and the pollen actually arriving and being deposited on the soil surface, where it becomes enmeshed and preserved in the stratified organic deposits. It should indicate the degree to which pollen preserved in the vlei is representative of the fossil pollen

data ie. whether the pollen preserved in the vlei is representative of the overall pollen rain.

When comparing the pollen trap spectra to the surface sample spectra, it should be remembered that the pollen sources and aerodynamics of the traps are significantly different. The pollen trap receives predominantly wind-blown pollen, whereas surface samples which are integrated over a number of years receive smaller proportions of wind-blown pollen and more insect-pollinated taxa and water-borne pollen types. This feature should be borne in mind when examining the contemporary pollen spectra from the Cederberg.

The pollen trap spectra seem to have higher percentages of arboreal, wind pollinated taxa than the surface sample spectra as shown by the abundance of Salicaceae pollen in N8, N9, N10 and N11, as compared to Ns8, Ns10 and Ns11. Taken as a whole, Asteraceous pollen was present in greater frequencies within the surface sample spectra. Many Asteraceous shrubs are anemophilous and therefore, it is expected that their contribution to the pollen trap spectra will be higher. This is not always the case, as is apparent in Figures 5.3 and 5.4. The pollen trap spectra do however have a greater diversity of pollen types. Pollen trap N9, situated at ground level within the vlei, had 25 different pollen taxa whereas the surface sample at this point only had 21 taxa. This may be associated with the fact that airborne pollen or pollen transported in the form of pollen rain is carried over greater distances than pollen movement on or near the surface. Another point of interest in when comparing the two spectra is that fungal spores are seldom found in the surface samples, whereas frequencies of 3.5% are found in the pollen trap spectra. This difference is due to poor preservation in the soils, buoyancy and abundance of spores in the atmosphere.

Modern pollen samples broadly reflect the present vegetation patterns on the Nuweveldberg Range, but on close examination

and by comparison with the vegetation composition, several anomalies are revealed. Although no detailed vegetation mapping was done, preliminary mapping of the area and composition of the vegetation assemblages was undertaken. The present vegetation communities seem to have a greater number of species than those present in the pollen traps and in particular, the surface sample spectra. Proximity to the pollen source and chance factors could also produce variations between the pollen spectra and the vegetation. These factors, which are not considered to be serious problems, should be remembered when interpreting fossil pollen spectra and reconstructing vegetation patterns.

6.4.2 VEGETATION HISTORY INFERRED FROM FOSSIL POLLEN DATA.

In contrast to the complex stratigraphy of the Winterberg and Compassberg vleis and other similarly-situated vleis in southern Africa, the accumulation of sediments in the Nuweveldberg seems to have been relatively simple during the period involved. It is possible that the Nuweveldberg vlei, spanning the last 760 years, is geomorphologically similar to that of the Compassberg and Blydefontein. Although only basal dates are available for the Nuweveldberg sequence, it can be assumed that accumulation rates have remained approximately constant throughout the core. At any rate, there are no signs of marked geomorphological and hydrological changes within the sedimentary record other than the onset of organic deposition some 760 years ago.

The organic content of this core is slightly higher than that of the Compassberg and Winterberg (13.1%), while pollen densities are comparable to those of the Winterberg core. These density values are a measure of pollen concentration (Colinvaux, 1978) and remain relatively constant throughout this time span, with slight increases associated with fungal spores. The pollen sum used to determine the frequencies of each taxon, excludes the fungal spore counts. The consistency in pollen densities is attributed to the

relative consistency of the stratigraphy and conditions suitable for the preservation of pollen grains. The pollen concentrations from these organic soils are considerably lower than those obtained by Scholtz (1986) from the highly organic Norga peats. The Norga peats appear to be more suitable for the preservation of pollen grains and are examples of some of the few true peats in South Africa.

The palynological spectra obtained from Bokkraal core 1 and core 2 are comparable and have similar pollen assemblage zones. The similarity of these two cores, which are taken 1.5m apart, further substantiates the assumed stratigraphic stability of this vlei. Within Bokkraal core 1 and core 2 pollen diagrams (Figures 5.7 and 5.8) the overall percentages of the major taxa of the local environment, ie. Cyperaceae, Juncaceae, Labiatae and Ranunculaceae, do not fluctuate greatly throughout the time span of the pollen diagrams, indicating an established moist vlei environment which has not changed markedly over the past 760 years. Within the regional environment, the occurrence of Campanulaceae and *Cliffortia arborea* pollen which are both indicators of moister environments, the associated high Poaceae pollen percentages and the onset of organic sedimentation at the base of the core (zone Na), indicate a relatively moist climate prevailing during this period. A gradual shift to a somewhat drier regional environment in which Asteraceae, Bignoniaceae and Aizoaceae pollen frequencies are well represented and an associated decline in the frequencies of grass pollen, Caryophyllaceae and other indicators of mesic conditions is then apparent. In sub-zones Nb111 (core 1) and Nb11 (core 2), there is a peak in percentages of Poaceae, Oleaceae (core 1) and Salicaceae appears for the first time. These fluctuations in pollen frequencies suggest slightly mesic conditions within sub-zone Nb111, with pollen spectra indicative of drier environments in subzones NbII and NbIV. The increasing frequencies of Poaceae pollen in zone Nc are suggestive of a return to a moister Nuweveldberg environment, where moisture

availability probably increased and conditions were again suitable for *Merxmuellera* grasslands. This idea is at variance with the generally accepted premise of Acocks (1953), that disturbance and overgrazing in the recent past has resulted in the eastward extension of the Karroid and desert communities in southern Africa. The summary pollen diagram (Figure 6.3) shows an increase in Poaceae frequencies over the last 25cm and a peak at 55cm. The vlei, herbs and heath elements remain consistent throughout the period of sedimentation. The contribution of pollen from Karroid shrubs declines slightly, whereas the frequency of the arboreal element increases over the last 760 years. The increase in the arboreal element, particularly in the top 25cm, is associated with the increase in abundance of *Acacia karroo*, as evidenced in Figure 5.7. A marked increase in the pollen frequency of Karroid shrubs occurs at a depth of 25cm.

Within zone Nc, *Stoebe, Elytropappus* and Chenopodiaceae pollen frequencies are well represented in core 1, while Fabaceae and Campanulaceae pollen frequencies are well represented in both cores - these trends may indicate disturbance within the vegetation rather than decreased moisture availability. The high frequencies of these pollen types may be associated with the change in land-use due to the occupation of the plateau by the Khoi-Khoi pastoralists, who replaced the San hunter-foragers who had occupied the area (Sampson, 1986). The arrival of Dutch Trekboers and stockherders in the early 1700's (Sampson, 1985a) seems to have had little noticeable impact on the vegetation of the upper plateau. The simultaneous increase in percentages of Poaceae, *Acacia* and *Populus* pollen in zone Nc could be interpreted as being a result of sedentary agricultural practices which began some 250 years ago, as opposed to nomadic hunter-gatherer and pastoral management.

Although there is no direct correlation between pollen influx and charcoal counts, the charcoal counts (Figure 6.3)

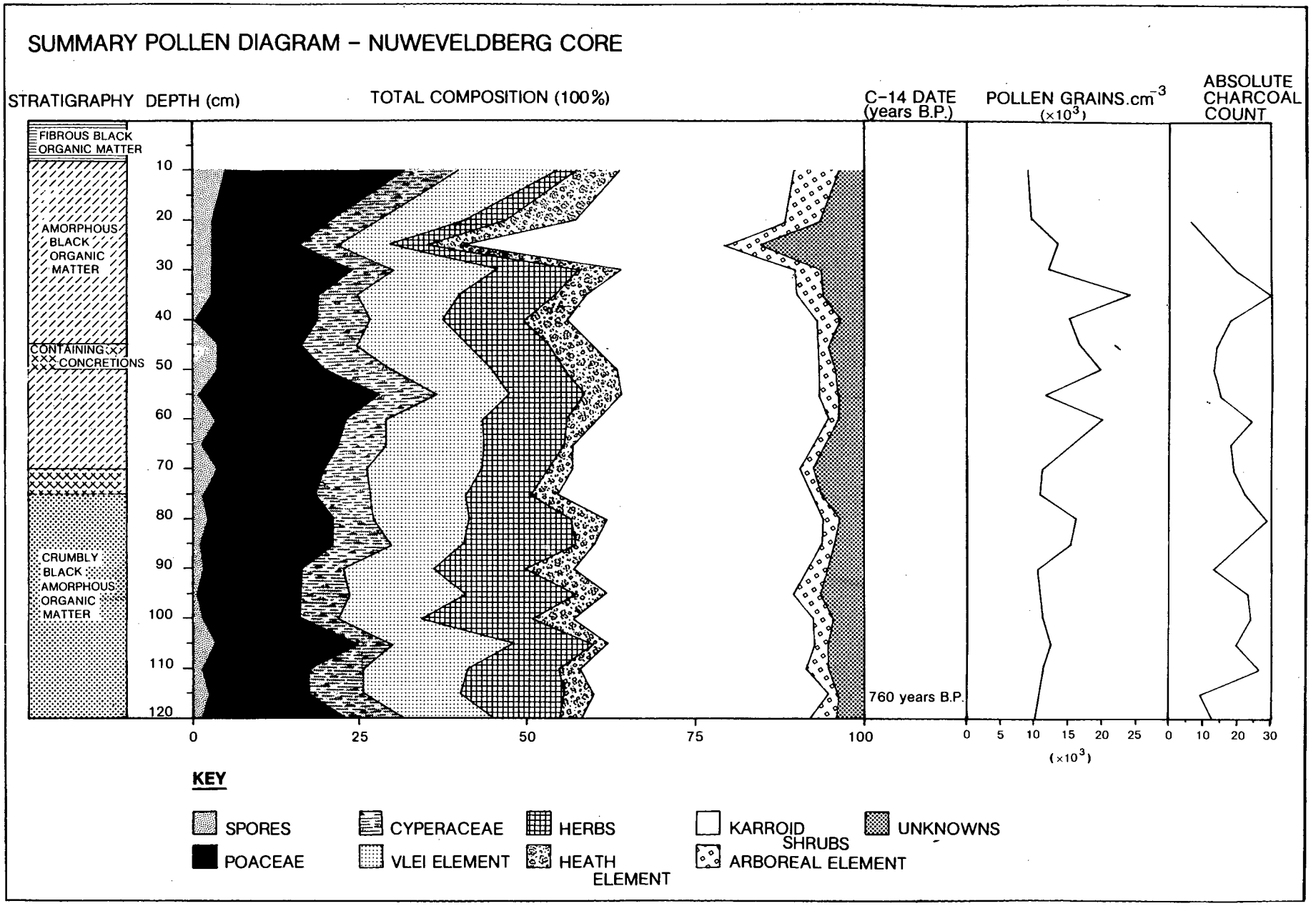

Figure 6.3 Nuweveldberg summary pollen diagram. The pollen sum equals 100% and is divided into indicator elements.

show that an increase in charcoal fragments is often followed by a decrease in pollen grain density, as shown at depths of 35cm, 60cm and 80cm. This is as one might expect, as there is a depletion of the vegetation cover and an associated lowering of pollen production. The charcoal counts yield some information about the frequency of veld fires. Natural lightning fires on the Nuweveldberg in the present day are unusual (H. Braak, pers.commun., 1987) and therefore, these changes in fire frequency may be associated with human-induced vegetation changes. The fires seem to increase during the more xeric period (zone Nb), when the Khoi-Khoi herders are thought to have first occupied this mountainous area. If a linear age-depth relationship is assumed for the Bokkraal sediments, the date of this xeric period (zone NbII) is extrapolated as being about 600 BP.

The trends and implications discussed so far, particularly the rise in grass pollen in the recent past, seem somewhat paradoxical especially as conventional wisdom purports a decline in veld quality which is presumably associated with a decline in grassiness. However, the application of multiple discriminant analysis does help to further unravel the vegetation history of this area.

6.4.3 STATISTICAL MANIPULATIONS.

Multiple discriminant analysis derives palaeovegetation categories from the fossil pollen data which correspond broadly with the three contemporary vegetation assemblages identified in this area. Using this statistical analysis the pollen diagram is divided into five zones, representing small, but significant changes in vegetation patterns and hence fluctuations in environmental conditions. These zones were not all apparent from intuitive, subjective techniques, but are clearly evident when the statistical procedures, based on fossil data, are implemented.

The contemporary pollen data from both surface samples and pollen traps were also used in the analysis. The high

percentage of correctly classified pollen trap samples (100%) and to a lesser extent the surface samples (82% correctly classified) imply high reliability in the palaeovegetational reconstruction of fossil pollen data. Although the contemporary data set is small (n=11), each of the pollen assemblages are clearly separated into distinct vegetation assemblages on the basis of their pollen rain characteristics. The surface sample spectra which has 82% of the samples correctly classified, are not as well defined as the pollen trap data. The modern analogue probabilities for Karroid Brokenveld may be attributed to the diversity of plants occurring in this assemblage and the age since disturbance, which would influence the successional stage and species diversity. It was previously noted (Section 6.4.2) that pollen spectra from the surface samples are less defined than those of the pollen trap spectra. Within the surface sample spectra, the canonical scores and group centroids (Figure 5.12) of Merxmuellera Mountainveld and the disturbed Mountainveld are relatively close to one another, as are those for the Upper Karoo and Karroid Brokenveld. This indicates that the disturbed Mountainveld vegetation has affinities for the Merxmuellera Mountainveld and similar affinities are apparent between Karroid Brokenveld and the Upper Karroid vegetation. Replication of the surface sample data or a larger data set would therefore improve the definition and representivity of each assemblage - a conclusion echoed by others using this type of data (Liu and Lam, 1985).

In general, the probabilities of a modern analogue are high for the modern pollen samples - once again pollen trap spectra are more reliable than the surface sample spectra. Within the surface sample spectra, low modern analogue probabilities are apparent for the disturbed Mountainveld category. This is anticipated as the disturbed areas have a variety of taxa, particularly ruderals, and there are few disturbed areas which have the same species composition.

Therefore, one is seldom able to duplicate or replicate the pollen spectrum. The contemporary pollen data set has however, produced a reliable representation of the surrounding vegetation and thus forms a reliable data base for palaeovegetational reconstructions.

Discriminant analysis has proved to be a useful tool in palaeovegetational reconstruction, particularly for determining whether modern analogues exist for the fossil pollen assemblages and for identifying misclassified zones. Subtle vegetation changes, which are not clearly depicted by means of intuitive subjective zoning or conventional ordination techniques, were identified eg. disturbed Mountainveld.

At the onset of organic sedimentation, 760 years ago, Merxmuellera Mountainveld prevailed on the Nuweveldberg (Figure 5.13). This, together with the presence of moisture-indicating taxa (Table 6.1), suggests that conditions were more mesic than at present on the Nuweveldberg and that conditions were probably similar to those of the present Compassberg grasslands. During zone Nb, Karroid Brokenveld prevailed, which suggests a drier period that is interrupted by moister conditions when the more mesic Upper Karroid vegetation prevailed. The change to Upper Karroid vegetation (zone Nb11) during a period when Karroid Brokenveld prevailed is due to the fluctuating moisture availability and the sensitivity of this vegetation to disturbance by Khoi pastoralists as suggested by Sampson (1985b).

In the uppermost zone, which represents the past hundred years or so, the vegetation assemblage is classified as Merxmuellera Mountainveld. The zonal index (1.2-1.5) is intermediate, suggesting that it does in fact represent a disturbed type of Merxmuellera Mountainveld or a grassveld that has a considerable Karroid component. Discriminant analysis classified the upper section of the pollen diagram

6.5 RECONSTRUCTION OF THE CEDERBERG VEGETATION HISTORY.

6.5.1 CONTEMPORARY VEGETATION-POLLEN RELATIONSHIPS.

No adequate contemporary pollen studies had previously been undertaken in the fynbos vegetation and it was therefore necessary to establish the pollen-vegetation relationships which exist. A comparison of the surface sample spectra and the pollen trap spectra is essential, particularly in a vegetation dominated by entomophilous and zoophilous taxa.

i. Pollen Trap Spectra.

Pollen traps located within the vlei environments produce spectra which are a fair reflection of the surrounding vegetation. The pollen traps situated 1m above the ground collect more "regional" pollen than the traps at ground level, which have higher local percentages. Asteraceae and Bruniaceae are not usually found in the vleis, although they are common in the extralocal vegetation; both are notable pollen contributors to traps on 1m stakes set in the vlei. Higher frequencies of pollen (4%) from *Widdringtonia cedarbergensis* within traps C10 and C11 is a good reflection of the surrounding regional environment. *Widdringtonia* is restricted to the upper plateau and rocky peaks of the mountains which surround Sneeuberg Vlei. A change in the abundance of these trees should, therefore, be shown in the fossil pollen spectrum taken from the core at Sneeuberg Vlei.

The pollen traps located in the cedar stands (C12 and C13), with an ericaceous understorey, present a pollen spectrum which is not a very accurate reflection of the vegetation. The high Restionaceae percentages within these spectra are attributed to the large vlei located adjacent to the rocky outcrop of cedars. *Widdringtonia* pollen percentages are low, considering there is a sparse canopy cover of these trees, many of which are struggling to survive and probably have a low pollen production. The pollen appears to be relatively well dispersed, as frequencies comparable to C12

and C13 are apparent in the vlei samples (C10 and C11), located about 1km away.

Ericaceous Fynbos covers vast areas, but varies with regard to species composition. The site of traps C1 and C2 is significantly moister and has a higher species diversity than the site of traps C5 and C6. The latter site is drier and dominated by ericaceous and asteraceous shrubs. This variation in vegetation is reflected in the pollen spectra from the two sites. Pollen spectra from traps C1 and C2 display low Ericaceae frequencies from an area which has a relatively high percentage cover of *Ericas*. This is attributed to the entomophilous nature of this family.

Proteoid Fynbos is dominated by a dense canopy of *Protea laurifolia* and *Protea nitida* on the lower, drier slopes. It has a sparse understorey of sclerophyllous shrubs including Asteraceae, Fabaceae and Ericaceae. Although Proteaceae pollen contributes a considerable proportion to the pollen spectrum, it appears to be under-represented when compared to the percentage cover. This may be attributed to the entomophilous nature of Proteaceae and its low pollen production. Poaceae percentages are notably higher in the Proteoid spectra, suggesting that these assemblages are established in the drier, rocky areas which is indeed the case in the Cederberg.

The pollen spectra from the Succulent Karoo, which is composed of pollen from Asteraceous shrubs and succulents is a good reflection of the xeric, succulent, Karoo vegetation. Mesembryanthemaceae, which is abundant in spring, is poorly represented within the pollen spectra. This may be attributed to the predominance of entomophilous taxa and a low pollen production. The transition from Fynbos to Karoo vegetation is obvious from the pollen spectrum, especially with the notable decline in Restionaceae.

When comparing spectra from the 1m poles to those at ground level, no marked differences are apparent. It does appear that the traps at ground level have consistently higher percentages of local taxa, particularly Poaceae and Restionaceae, whereas traps at 1m have slightly higher percentages of arboreal and regional components. Similar trends are observed in the central Karoo, indicating that the fynbos vegetation behaves in a similar way to the Karoo vegetation, even though it is dominated by entomophilous taxa.

ii. Surface Sample Spectra.

Surface samples are important in the fynbos, where entomophily is more common than in the Karroid environments (Rebelo, 1987). Surface sample spectra from the vlei environment appear to be a fair reflection of the prevailing vegetation. The percentage of vlei elements in Cs10 is greater then in Cs4, which may be attributed to greater moisture availability at Sneeuberg Vlei than at Driehoek Vlei. The surface sample spectra from the rocky outcrop which has numerous cedar trees and an ericaceous understorey is a fair reflection of the shrubby vegetation prevailing in the area, but the arboreal component is under-represented. Meadows and Meadows (1988) also found the arboreal taxa from the Winterberg to be under-represented within the surface sample spectra.

Surface sample spectra from Ericaceous Fynbos are a relatively poor reflection of the surrounding vegetation. Although Cs2 is adjacent to Driehoek Vlei, Cyperaceae and Restionaceae appear to be over-represented. Cs6 is from an area with a dense cover of *Erica* and yet they only contribute 8% to the pollen spectrum. Ericaceae members obviously have a low pollen production and poor dispersal mechanisms as compared to Fabaceae, which has a similar percentage contribution to the pollen spectrum, but only had a 10% cover. The surface sample pollen spectrum from heathlands on Table Mountain show similar trends to those of

the Cederberg, with Restionaceae pollen contributing 50% and Ericaceae pollen contributing about 23% (Martin, 1968). This feature is also apparent in the surface sample spectra from the heathlands on the Winterberg (Meadows and Meadows, 1988), but Scott (1989) finds high Ericaceae frequencies in surface samples on high peaks in the Drakensberg. Within the Proteoid Fynbos, *Protea laurifolia* forms a relatively dense overstorey, with a shrubby understorey dominated by Asteraceae and Fabaceae. These environments do not, therefore, yield a pollen spectrum which is a good reflection of the contemporary vegetation patterns in the catchment area. Proteaceae pollen is also poorly represented within the pollen spectra from the Table Mountain heathlands (Martin, 1968). The contribution of vlei elements is lowest in this spectrum, indicating xeric conditions which are indeed prevalent on the rocky mountain slopes.

iii. Pollen Trap Spectra versus Surface Sample Spectra.
A comparison of the pollen trap spectra and the surface sample spectra is essential to assess the representivity of these pollen spectra. This comparison offers a degree of representivity to the fossil pollen data and indicates the degree to which pollen preserved in the vlei is representative of the fossil pollen data.

The surface sample spectra are remarkably similar to the pollen trap spectra from ground level viz. C2, C4, C6, C8, C11, C13 and C16. The similarity of the pollen spectra from traps at ground level and surface samples suggest that this difference in representivity as compared to traps at 1m, is not due to preservation anomalies of the pollen in the soil surface, but is probably due to the life forms, structure and stratification of the fynbos vegetation. Regional elements are represented in greater frequencies in the pollen trap spectra, as are arboreal taxa. In both spectra from ground level, the vlei elements represent a greater percentage than in the pollen trap spectra from 1m above the

ground. Poaceae pollen is particularly well-represented and in some cases, over-represented in the surface sample spectra. This may be attributed to the abundant pollen production of this taxon or to the life-form of this family.

A significant observation which emerges from this comparison is that vlei elements are over-represented and arboreal elements under-represented within the surface sample spectra. In general fynbos elements, for example Ericaceae and Proteaceae, are under-represented in both pollen spectra, but this is associated with the entomophilous nature of these taxa. Notwithstanding the problems associated with these modern pollen spectra, the overall results from the pollen trap spectra, particularly those at 1m above the ground, proved to be a better reflection of the vegetation communities prevailing in the catchment area than the surface sample spectra.

6.5.2 VEGETATION HISTORY INFERRED FROM FOSSIL POLLEN DATA. A. DRIEHOEK VLEI.

The pollen diagrams and their implied vegetation fluctuations are discussed separately, followed by a comparison of the two cores and the implications thereof. The array of different pollen types throughout Driehoek core is remarkably similar to those of the modern pollen samples collected both at the surface and in the pollen traps. This suggests that pollen has been well preserved in the organic sediments and no large losses in pollen have occurred during sampling or sample preparation. Conclusions drawn from changes in the frequencies of a single taxon must be tentative, as reasons for these changes may be diverse and in some cases due to technical and methodological errors rather than vegetation changes. Only if a number of taxa show fluctuations at the same time, together with additional archaeological and geomorphological indicators, can trends and inferences be made regarding environmental changes. The

majority of unknowns are crumpled, which is attributed to abrasion and hydraulic action within the vlei environment. This, together with the increase in crumpled grains in the layers above and below the wet layer, indicates that moist, boggy conditions prevailed in this vlei during the past 14 000 years. Other than the wet layer which was not sampled, few stratigraphic inconsistencies are evident in the core, suggesting that the sediment has accumulated in stratigraphic layers which form a logical chronological sequence.

The initiation of organic sedimentation at 14 600 BP probably represents a shift to moister conditions with a denser vegetation cover than had previously prevailed. When examining the dating, it appears that deposition occurred at a decreasing rate between 3 230 BP and 10 090 BP and between 10 090 BP and 14 600 BP ie. at a rate of 28.4 and 14.4cm per 1 000 years respectively. In the last 3 230 years there appears to have been more sediment deposited over time ie. 80.5cm per 1 000 years. When examining the pollen influx, there are higher pollen densities from 3 230 to 14 600 BP, as opposed to the last 3 230 years (Figure 6.4). Bearing in mind that the last 3 230 years have been moist, the pollen densities may not in fact have increased as the time intervals per unit volume of sediment collected are greater in the latter section. If the data are re-calculated using a uniform time scale, it appears that pollen densities would remain relatively constant over time and not decrease in the latter period of deposition.

The summary pollen diagrams (Figure 6.4 and 6.5), which group a number of taxa according to vegetation assemblages, simplifies the pollen diagram and displays trends more clearly. Figure 6.4 shows that no major changes have occurred in the catchment area during the period of sedimentation. The shrubby fynbos element, which includes most of the typical sclerophyllous taxa and is the dominant vegetation category, shows no major changes in pollen

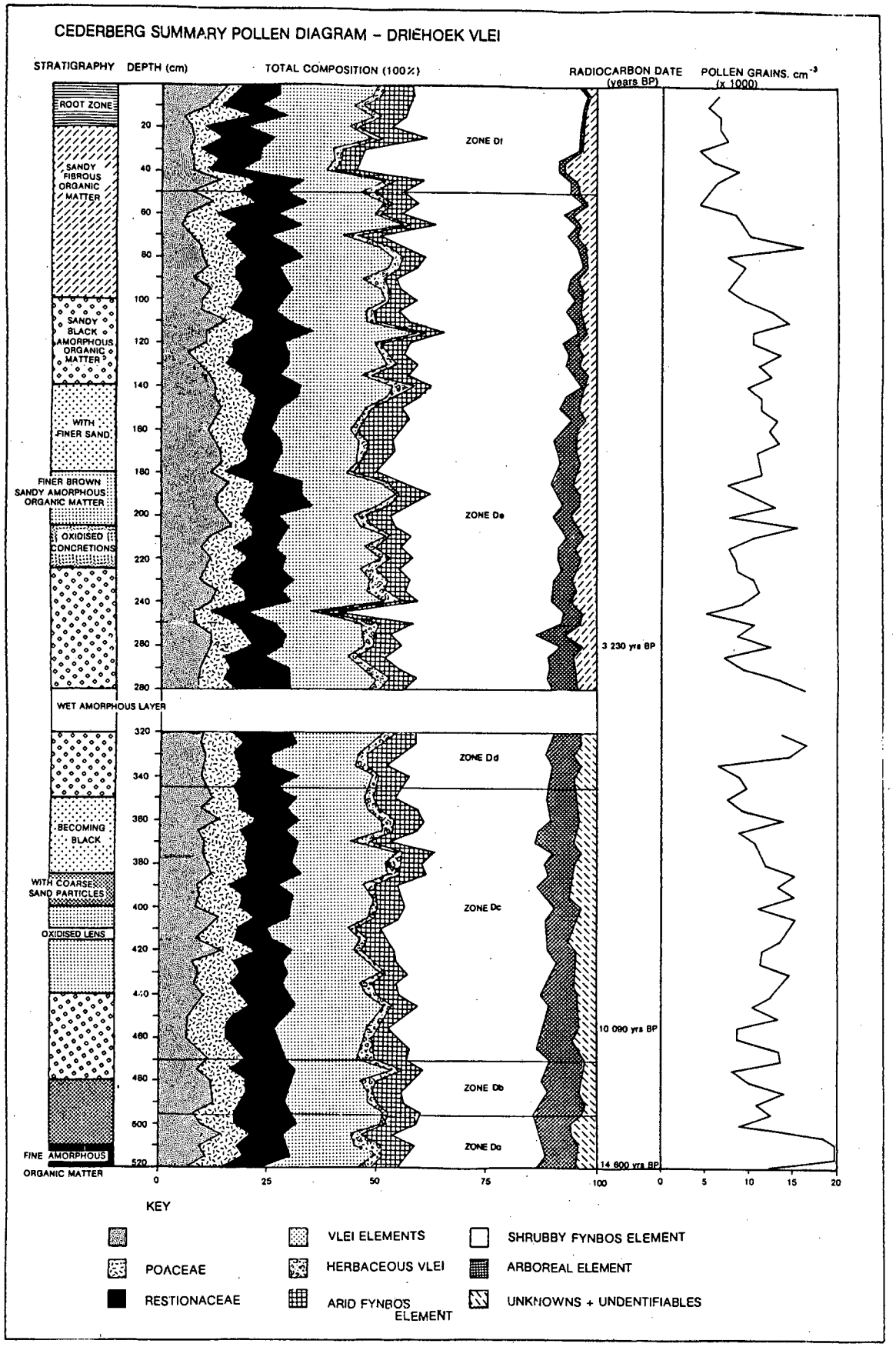

Figure 6.4 Summary pollen diagram from Driehoek Vlei, Cederberg Mountains. Families showing similar environmental requirements are grouped.

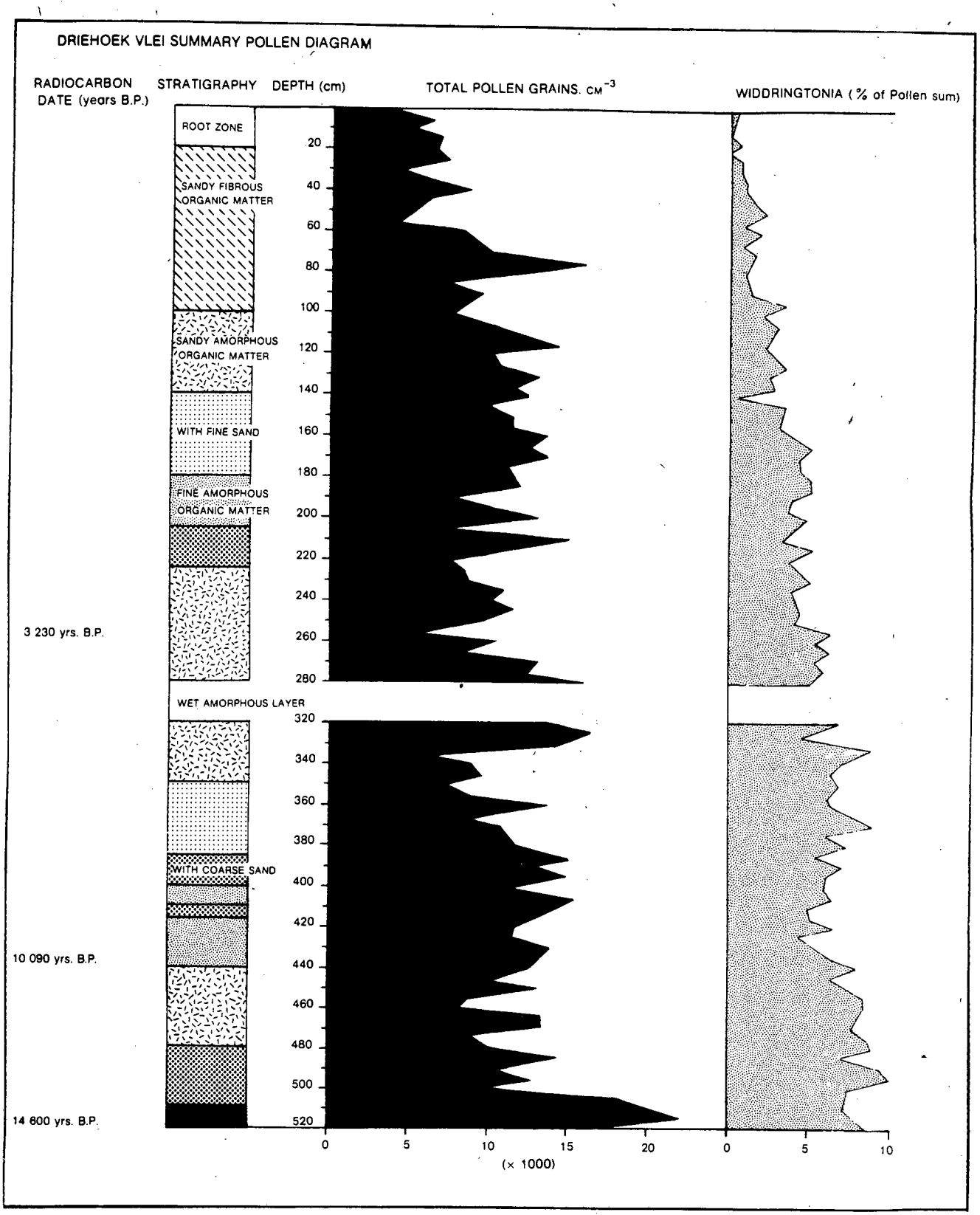

Figure 6.5 Driehoek summary pollen diagram showing the decline of *Widdringtonia cedarbergensis* over the last 15 000 years.

abundance. However, there appears to have been a gradual increase in percentage composition from 32% at the onset of sedimentation to 38.5% at the present time. The gradual decline in Poaceae frequencies, particularly in zone Df, and the more marked decrease in the arboreal elements from the base of the core upwards, is apparent. This arboreal element is composed predominantly of *Widdringtonia cedarbergensis*, which is presently only found in low numbers on the uppermost plateaux. The Driehoek pollen diagram (Figures 5.17, 6.4 and 6.5) has six pollen assemblage zones, suggesting small but significant fluctuations in the fynbos vegetation. Within zone Da indications are that moister conditions prevailed in the vlei than those of the present vlei environment. High percentages of taxa indicative of moister environments together with the onset of organic sedimentation suggest that the moister conditions were probably widespread and influenced the regional environment. The fluctuations in pollen frequencies throughout the subsequent zone Db suggest that conditions in the catchment area were somewhat drier during this period than those of today and that Proteoid Fynbos occurred in this area.

The pollen spectrum from zone Dc is similar to that of Ericaceous Fynbos but has consistently high frequencies of cedars. This suggests that a canopy of cedars in densities far greater than the present time prevailed. Within zone Dd the indications are of an increasing moisture availability and an expansion of the vlei environment. Restioid Fynbos dominates until the extremely moist stratum for which no dates are available, is encountered. The upper half of the diagram, or the period after 3 230 BP becomes progressively drier. Within zone De, the indications are of an Ericaceous type of fynbos occurring, with a canopy of cedars which became progressively sparser with time. The fluctuations in zone Delll suggest a greater aridity than the present, when a more mesic to arid fynbos might have prevailed. Zone Df is characterised by a number of fluctuations suggesting disturbance by Khoi herders in the environment. This

disturbance is probably associated with the increased burning regime and grazing by domestic stock.

The main indications are that no marked changes occurred throughout the period of deposition and mesic mountain fynbos has been established in this area for at least the last 14 000 years. Within the surface 100cm or so (zones DeIII, DeIV and Df), there are slight increases in a number of taxa such as Juncaceae, Liliaceae, *Stoebe*-type, Proteaceae and an intermittent peak in Pinaceae. These increases, which probably represent the last few hundred years to perhaps one thousand years of sedimentation, are associated with families with a "weedy" habit and may be related to anthropogenic influences, or taxa which perform well after fires. The implication of such changes is one of increased disturbance towards the present time. Over the same depth (zone Df), there is a corresponding decrease in a number of pollen taxa, particularly Poaceae and Amaryllidaceae and an absence of Caryophyllaceae, Santalaceae and Myricaceae. These changes support the contention that human-induced environmental disturbance is responsible for these fluctuations. There is a gradual decline in Cupressaceae *(Widdringtonia cedarbergensis)* pollen from about 150cm onwards, but this becomes particularly evident at about 100cm and then declines to negligible frequencies within the last 20cm (Figure 6.5). This decline in *Widdringtonia* pollen within the Driehoek pollen spectrum accords with the present speculations by Manders (1986), that the reduction in the abundance of *Widdringtonia* trees during the last century may be attributed to over-exploitation.

B. SNEEUBERG VLEI.

The trends indicated in the Sneeuberg pollen diagram accord relatively well with those from Driehoek Vlei, but the difference in altitude of 400m does present some noticeable differences in the pollen spectrum.

Sneeuberg core, which dates back to 9 640 BP, is shallower than the core from Driehoek Vlei, and bears evidence for fluctuations in the vegetation assemblages at higher altitudes. When examining the dating, it appears that deposition occurred at varying rates throughout the sedimentation period. The sedimentation rates vary from 33cm per 1 000 years in the top 65cm, 53cm per 1 000 years in the second time interval and 28cm per 1 000 years in the bottom 175cm. The average sedimentation rate of 32cm per 1 000 years is slightly higher than that occurring at Driehoek Vlei. The density of pollen grains does not seem to be influenced by the organic content of the sediments, as was found in Driehoek Vlei. The densities remain consistent throughout the core, displaying no differential preservation - both the organic content and the pollen densities do however show a gradual decline towards the surface of the core.

The summary pollen diagram (Figure 6.6) shows few, if any, dramatic fluctuations within the pollen spectrum for the Sneeuberg catchment area during the past 9 600 years. A gradual decline in the arboreal element has occurred since the onset of organic sedimentation, which is attributed to the decline in *Widdringtonia cedarbergensis* (Figure 6.7). Other trends include the gradual increase in Restionaceae, Poaceae and herbaceous components. Associated with these changes is a gradual decline in the shrubby drier fynbos component, from 40% at the base of the core to 25% at the surface.

The Sneeuberg pollen diagram is divided into five zones, none of which show marked differences in pollen frequencies. Within zone Sa, the abundance of taxa indicative of moist conditions within the local and regional environments, together with the onset of organic sedimentation at 9 640 BP, indicate that conditions moister than the present prevailed. The relatively high frequencies of *Widdringtonia* and Proteaceae pollen, which are usually under-represented,

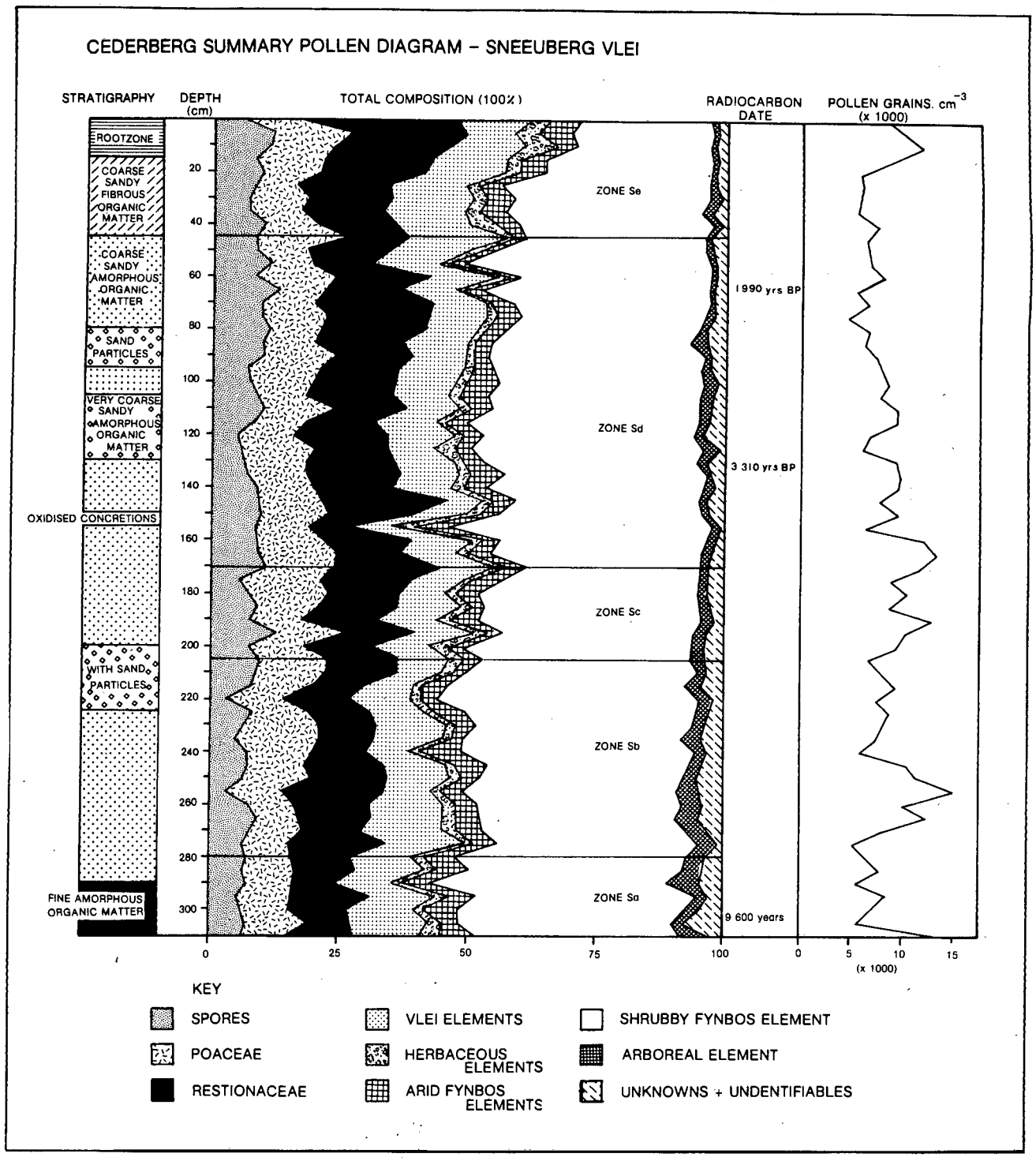

Figure 6.6 Summary pollen diagram from Sneeuberg Vlei on the Cederberg.

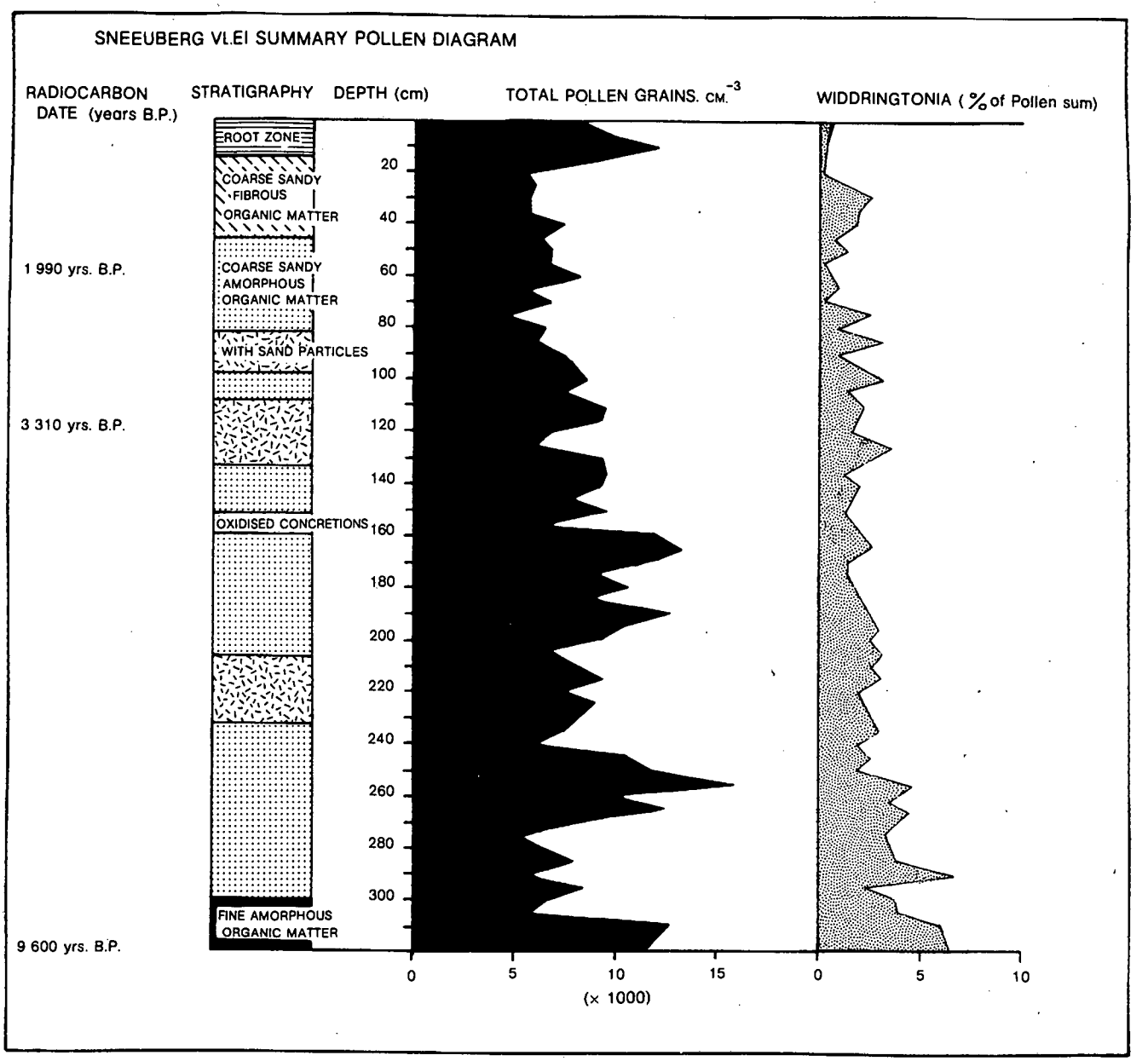

Figure 6.7 Sneeuberg summary pollen diagram showing the decline of *Widdringtonia cedarbergensis*.

indicates that they were abundant on the upper Sneeuberg plateau and suggest that a canopy or overstorey of Proteoid Fynbos interspersed with cedars prevailed during this period. Within zone Sb, the indications are that Ericaceous Fynbos occurred, with a number of small climatic fluctuations which suggest a modification in the composition of the overstorey and the abundance of *Widdringtonia*. The slight decline in *Stoebe*-type, thought to be *Stoebe plumosa* which is an indicator of cooler conditions, suggests warmer conditions during the latter part of this zone. In the Cederberg, *Stoebe* is also an indicator of winter burning and therefore this decline may indicate a change in the burning regime by hunter-gatherers, to predominantly summer periods. Zone Sc, which is characterised by small increases in taxa indicative of drier environments (Aizoaceae, Cruciferеae) signifies a decrease in the moisture availability and the establishment of a mesic Asteraceous Fynbos. The pollen frequencies within zones Sd are indicative of an Ericaceous Fynbos in which the overstorey of cedars has declined to their present distribution on the rocky outcrops.

Within the uppermost zone, indications are of a moist vlei environment in which Restioid Fynbos predominates. The overall implication is one of increased human disturbance towards the surface. The good representation of ruderal taxa (eg. Malvaceae, Ranunculaceae, Oxalidaceae) and the introduction of Pinaceae support the idea that human-induced environmental disturbance is probably responsible for these fluctuations.

A combination of the trends indicated in the two pollen diagrams produce a clearer picture of the environmental and vegetation changes in the Cederberg over the past 15 000 years. An examination of the two diagrams shows that there are no marked changes throughout the period of deposition. This suggests that mesic Mountain Fynbos has been maintained on the Cederberg for at least the Holocene period, although the precise composition of the communities may have been

altered. The small amount of variation in the pollen diagrams is remarkable and an anomaly, as most pollen diagrams from southern Africa, which cover this sort of time span, show prominent fluctuations (Scholtz, 1986; Scott, 1989). In addition, there is no indication of a marked environmental change at the Pleistocene/Holocene boundary within the Driehoek sequence. This feature, together with the lack of variation is believed to have important implications for the development and maintenance of species richness in the Cederberg plant communities and in the Fynbos Biome as a whole. A problem which should be borne in mind when examining the fynbos vegetation is that there is a vast pool of fynbos species belonging to the same supraspecific taxa, for example, there are Restionaceae, Ericaceae and Asteraceae that occupy a wide range of habitats from the coastal plains to the fynbos of high altitudes. As Campbell (1985) has shown, Restioid Fynbos occurs in both permanently waterlogged vleis and well-drained deep sands at the extreme for fynbos. Therefore, inferring environmental changes from changes in the family-level spectra is highly problematic. One way of reducing this problem is to examine the combination and relationship of families within the pollen spectra before inferring environmental fluctuations.

Both pollen diagrams show signs of disturbance in the top 100cm, as evidenced by the increase in weedy species. According to the dating of the sediments, this disturbance predates the arrival of European settlers in the Cape and seems likely that occupation by Khoi herders, albeit seasonal and San hunter-gatherers (Parkington, unpublished) may have increased the disturbance. A possible cause of this disturbance could have been an altered fire regime. The decrease in a number of taxa (including Cyperaceae, Asteraceae and Ericaceae) within the surface zone of both cores supports the implications that human-induced environmental disturbance was responsible, a disturbance

which is particularly marked at higher altitudes during the top 20cm of organic sediment.

A number of differences are however, evident in the two diagrams. Proteaceae seem to increase markedly near the surface of Driehoek Vlei, but decrease during the same period in Sneeuberg Vlei. In attempting to interpret this difference it is vital to understand the contemporary ecological situation. Driehoek Vlei is surrounded by a form of Asteraceous Fynbos with an overstorey of *Protea nitida*, whereas Sneeuberg Vlei is surrounded by Ericaceous Fynbos with *Protea laurifolia* forming Protea thickets or groves in the sheltered north-facing kloofs. According to Campbell (1986a) the locations of vegetation assemblages are influenced by moisture gradients, with the areas at lower altitudes being more xeric, and pedological factors, with soils of the higher altitudes having a higher clay content. One could speculate that, in addition to human disturbance around Sneeuberg, the increase in Proteaceae at Driehoek could be due to the increased intensity of summer droughts at low altitudes, hence favouring Asteraceous Fynbos, while cloud cover and condensation have maintained the moisture in the upper Cederberg where *Protea laurifolia* is more abundant. In addition, it has been suggested that during unfavourable conditions, Proteaceae are maintained by their effective root penetration into the rocky crevices (Meadows and Sugden, 1989).

The frequencies of *Widdringtonia cedarbergensis* indicate that this tree has not dominated the Cederberg during the last 14 600 years and that there are no assemblages from either the Sneeuberg or Driehoek cores which resemble what might have been a closed cedar forest. There are several stages at which the cedar pollen frequencies fluctuate, when correspondingly low total pollen frequencies suggest a major environmental disturbance. Most interesting is the gradual decline in *Widdringtonia* pollen from about 60 and 150cm onwards in the Sneeuberg and Driehoek pollen diagrams

respectively and then the decline to negligible frequencies in the top 20cm of Driehoek. This decline accords with the conclusion of Manders (1986), who proposes a sharp decline in cedar tree numbers during the last few centuries as a consequence of over-exploitation. The pollen diagrams hint however, that the ecological situation of *Widdringtonia cedarbergensis* on the Cederberg had been difficult for some time prior to the arrival of Europeans in the region.

The history of the Cederberg vegetation over the last 14 600 years has some important implications for the management of the cedar trees. Their demise must be viewed as part of a long-term process and at no stage during the available record do they appear to have been so numerous as to have constituted a "forest". This history of the Clanwilliam cedar is a history of a long-term decline in response to both environmental and anthropogenic factors and it may be that attempts to re-establish cedars over extensive areas of the Cederberg are doomed to fail.

6.5.3 STATISTICAL MANIPULATIONS.

i. Modern Pollen Data.

Multiple discriminant analysis compares fossil pollen assemblages from vleis to modern pollen assemblages collected from known vegetation regions. Contemporary pollen data from surface samples and pollen traps are used in the analysis. Modern pollen samples are classified using discriminant functions, into one of the *a priori* assemblages which include Proteoid Fynbos, Ericaceous Fynbos, Restioid Fynbos, cedars with an ericaceous understorey and Succulent Karoo. The high percentage of correctly classified pollen trap samples (100% correctly classified) and to a lesser extent surface sample spectra (71% correctly classified) indicate that these modern pollen samples form data bases which may be used to accurately determine analogue palaeovegetations. When examining the relationship between contemporary pollen spectra and the vegetation (Section

6.5.1) the pollen trap spectra appeared to be more representative of the surrounding vegetation assemblages.

The ordination plots show that although fynbos assemblages have close affinities for one another, the samples have little variation about their centroids and may be distinguished into assemblages on the basis of their pollen rain characteristics. In both data sets, the centroids of Proteoid, Restioid and Ericaceous Fynbos are relatively close to one another, indicating that they have similarities or share common taxa, while Succulent Karoo is clearly different to the other assemblages. Unfortunately there is no contemporary pollen data from the Asteraceous/ Undifferentiated fynbos which, on a moisture gradient, lies between the Succulent Karoo and Ericaceous Fynbos. Within the present data set there is a distinct geological boundary between the fynbos and the Succulent Karoo and thus, the strong separation between these assemblages is expected.

The vegetation zonal indices and modern analogue probabilities for modern pollen samples all approximate 100% or integer values, as they are from known vegetation assemblages in the Cederberg area. The surface sample spectrum is not as well defined, having a few intermediate indices and relatively low modern analogue probabilities. This analysis confirms the observation in Section 6.5.1, that the surface sample spectra are not entirely representative of the prevailing vegetation and replication of the samples or a larger data set is required to reduce the margin of error and the representivity of these data sets.

ii. Fossil Pollen Data - Driehoek Vlei.

Multiple discriminant analysis proved to be an extremely useful tool for classifying fossil pollen spectra into one of the *a priori* groups. Intuitive zonation of the pollen diagrams was difficult as no marked changes are evident. Discriminant analysis largely confirms the subjective

zonation as 62% of these samples are correctly zoned. The more subtle ecotonal or transitional areas proved to be even more difficult to identify visually. The probabilities of a modern analogue and the vegetation zonal indices of the fossil pollen data suggest that the contemporary plant communities on the Cederberg are suitable models for palaeovegetation patterns. The modern analogue probabilities are reasonably high, suggesting that modern analogues exist for most of these pollen assemblages. The modern pollen spectra which are used as analogues to determine this probability value are not separated into distinct vegetation assemblages as seen in Figures 5.19 and 5.20. This may account for the absence of probabilities of 1.0. Substantially lower probabilities are evident for palaeovegetations which have an overstorey of cedars, suggesting that the modern cedar communities are somewhat different to the palaeovegetation, which is thought to have had a denser canopy cover of cedar trees.

The zonal indices fluctuate continually, not only within the ecotonal areas. This suggests that the *a priori* vegetation assemblages are dynamic and constantly changing or adapting to the prevailing conditions. This feature is more explicit in the ordination plot, which shows a great deal of overlap between the different vegetation assemblages and no well-defined clusters. This shows that at no time during the past 15 000 years has the vegetation changed markedly from the mesic Mountain Fynbos which covers this area at the present time, other than the decline in *W.cedarbergensis*, which forms a sparse overstorey at higher altitudes.

Discriminant analysis indicates that at the onset of sedimentation 14 600 years ago, Restioid Fynbos occurred in the catchment area. It was replaced by Proteoid Fynbos and subsequently by Ericaceous and Proteoid Fynbos with a substantially denser canopy of cedars than exist today. From about 10 000 BP a variety of fynbos communities came and went, but Ericaceous Fynbos seems to be most common.

This initially had an overstorey of cedars which gradually declined. Approximately 4 000 years ago a moist phase is recorded, which was preceded by the dominance of Restioid Fynbos. After this moist period, the vegetation fluctuations suggest an increasing aridity and a change of vegetation from Ericaceous Fynbos to a drier undifferentiated Fynbos.

Although the shifts in plant community characteristics are subtle, they indicate an important shuffling of vegetation throughout the sedimentation period, an observation which may have important implications for the explanation of fynbos species richness patterns.

iii. Fossil Pollen Data - Sneeuberg Vlei.

The zones obtained from intuitive subjective methods are compared to those obtained from discriminant analysis. A total of 84% of the samples intuitively zoned are correctly classified into the five *a priori* groups. It is in the ecotonal areas or periods when the vegetation is adapting to changes in the environment that misclassification occurs. In general, most of the palaeovegetation assemblages confirm the zones except the assemblage described as "cedars with an ericaceous and proteoid understorey".

Discriminant analysis indicates that 9 600 years ago Proteoid Fynbos dominated the Sneeuberg catchment area. This was replaced by an Ericaceous Fynbos having an overstorey of Proteaceae and cedars, presumably denser than the present cedar stands. This was replaced by Ericaceous Fynbos which becomes progressively drier and was replaced by undifferentiated Fynbos. From about 4 000 to 1 000 BP mesic Ericaceous Fynbos dominates, with the most recent zone being moister than the preceding period and dominated by a Restioid Fynbos. The probabilities of a modern analogue all approximate 1.0, except the assemblages having an overstorey of cedars. This observation suggests that the modern cedar community, with its sparse canopy cover of largely senescent

cedar trees is slightly different from the dense cedar stands that occurred some 8 000 years ago. This feature is also observed at Driehoek Vlei.

This analysis broadly confirms the zones which were intuitively selected and suggests that the more subtle vegetation changes are not always clearly depicted by means of conventional techniques. It shows that small, but significant shifts in the fynbos vegetation assemblages have occurred on the upper Cederberg. This analysis confirms that fluctuations have not been marked and that the only vegetation assemblage which no longer exists in its original form is "cedars with an ericaceous understorey". Palynological evidence shows that the canopy of cedars was substantially denser than the present sparse cover of cedars or, at least, that pollen production by cedars was higher. The few surviving cedars do however, appear to be struggling to survive on the rocky outcrops of the upper plateau of the Cederberg.

iv. TWISA.

These classification techniques were applied to the fossil pollen data in an attempt to classify the pollen samples in a totally objective manner. No *a priori* assemblages are required and therefore no subjectivity is included until the end of the analysis when the environmental trends implied by the three axes on the ordination plot are examined.

TWINSPAN classifies the pollen spectra from **Driehoek** into five different vegetation assemblages (Figure 5.27) and identifies nine zones within the pollen diagram. These are listed in Table 6.2. This classification broadly agrees with the zones obtained from discriminant analysis. Discriminant analysis seems to be slightly more sensitive to vegetation changes as it identifies the ecotonal or transitional areas which are not identified using TWISA.

Zone	Depth of sample	Samples	Extrapolated palaeovegetation
9	1, 60 cm	1 & 2	Restioid Fynbos
8	80 cm	3	Undifferentiated Fynbos
7	160 cm	4	Ericaceous Fynbos
6	250 cm	5	Undifferentiated Fynbos
5	330 cm	6	Proteoid with restioid understorey
4	355 cm	7	Cedars with ericaceous understorey
3	410 cm	8	Ericaceous Fynbos
2	465 cm	9	Proteoid with Restioid Fynbos
1	490, 510 cm	10 & 11	Restioid Fynbos

Table 6.2 Palaeovegetation assemblages from random depths from the Driehoek spectrum, derived from TWISA.

TWINSPAN classifies the pollen spectra from **Sneeuberg Vlei** into two different vegetation assemblages (Figure 5.28) and identifies six zones within the pollen diagram (Table 6.3). The palaeovegetation is extrapolated from the pollen frequencies in the original pollen diagram and the results of discriminant analysis. The six zones are identical to those obtained using discriminant analysis, but once again ecotonal areas are not identified using TWISA. The two vegetation assemblages are poorly separated using TWISA.

Zone	Depth of sample	Sample no.	Extrapolated palaeovegetation.
6	25 cm	1	Proteoid Fynbos
5	70 cm	2	Cedars with ericaceous understorey
4	180 cm	3	Ericaceous Fynbos
3	220 cm	4	Undifferentiated Fynbos
2	250,275 cm	5 & 6	Ericaceous Fynbos
1	300 cm	7	Restioid Fynbos

Table 6.3 Palaeovegetation assemblages from the Sneeuberg spectrum derived from TWISA.

The TWISA results have confirmed the subjective zoning and the assemblages identified using discriminant analysis.

This classification is a useful means of checking the vegetation assemblage zones and produces a classification with a similar array of former vegetation types to those obtained from alternative methods, but in a simpler zonation format. This analysis does, however, show that the separation of vegetation assemblages within the Mountain Fynbos is extremely difficult within this data set. Although a shuffling of fynbos vegetation communities has occurred in response to environmental fluctuations throughout the period of sedimentation, these have been subtle and difficult to identify visually, as some families are common to more than one vegetation community.

6.5.4 IMPLICATIONS FOR FYNBOS SPECIES RICHNESS.

The conclusion that this part of the Fynbos Biome has experienced relatively little environmental change in the Late Pleistocene and Holocene is unexpected, since elsewhere on the sub-continent there have been frequent and major changes (Deacon and Lancaster, 1988). However, the fact that fynbos plant communities on the Cederberg have been altered in composition over the sedimentation period without ever having been seriously stressed and hence removed, is a potential factor in the speciation processes in the fynbos. Many ecologists have pondered the legendary species richness of the fynbos. The environmental complexity of the region coupled with environmental variability over time have frequently been cited as determinants of the species richness (Meadows and Sugden, 1989).

The overriding controlling factor in the distribution of fynbos vegetation in southern Africa is geology (Kruger, 1978), in this case the nutrient-poor Table Mountain Sandstone. Climate, which is the controlling factor in the Mediterranean-type biomes elsewhere in the world, for example the Californian Chaparral and the Chilean Matorral, seems to be of secondary importance in the fynbos (Specht, 1979). Cape fynbos communities have been shown to have

major differences from communities at analogous sites on other continents (Cowling and Campbell, 1983). Much of this divergence between the fynbos and the vegetation of California and Chile is attributed to the nutrient-poor soils on which fynbos has evolved. The situation is similar to that of Western Australia, where the Mediterranean-type biome is determined by the nutrients and not by the climate (Specht, 1979). Both the fynbos and the Australian heathlands have soils which are exceptionally poor in nutrients. The species diversity is not as high in the Australian heathlands as in the fynbos, a phenomenon which is attributed to the diverse terrain of the south-western Cape in contrast to the more uniform landscape of western Australia.

There have been few major shifts in climatic conditions over the past 15 000 years and the Last Glacial Maximum, although cooler than today, was probably wetter and therefore continuously supported fynbos vegetation. It has been suggested that during the glacial period the south-western Cape experienced moister conditions, whereas in the inland summer rainfall areas the moisture availability decreased. The last glacial period therefore, did not remove the fynbos communities and there has been an uninterrupted period of speciation and diversification of the fynbos flora, resulting in the high species diversity and endemism.

This is in direct contrast to other areas of the world in which Mediterranean-type shrublands occur. The last Glacial Maximum in the Californian Chaparral was extremely severe and forced the migration of many taxa, which constitute the Chaparral flora, to the drier surrounding areas (Raven and Axelrod, 1978). The Chaparral today resembles the weedy flora of the world and has evolved in response to recent climatic change and periodic droughts. There are however a large number of endemics (48% of the species), but the species diversity is not as high as that of the fynbos region (Raven and Axelrod, 1978).

The origin of the fynbos, about which there is much dispute (Deacon, 1983c), may have a role in explaining the species richness. According to Axelrod and Raven (1978), during the Miocene the sclerophyllous vegetation is considered to have occupied areas which are now desert, semi-desert and grassland. These authors hold that this rich sclerophyllous vegetation persisted in the present more arid areas during the Pleistocene, thereafter invading the present fynbos area. In response to glacial conditions and the expanding temperate forest, fynbos migrated into the now drier areas during the Pleistocene. According to Deacon (1983c), the fynbos was largely swept into its present area as a result of drier climates at the end of the Pleistocene, about 10 000 years ago. Taylor (1980) has argued against these ideas, stating that a vegetation assemblage like the fynbos, which is associated with a particular substrate (Cowling, 1983; Specht, 1979), cannot be considered to migrate as a unit and that the response to climatic changes was the adjustment of a range of individual taxa (Livingstone, 1975) and not mass migrations. The findings of this palynological investigation substantiate the ideas of Taylor (1980), showing that although the climate did change, the fynbos vegetation was able to survive by the shifting of different communities within the fynbos assemblage. The scarcity of evidence which dates from the present day arid areas to the Miocene period, hinders the solution to the migration of the fynbos assemblage.

The fynbos vegetation has, however, been maintained *in situ* and the geological boundary which forms the eastern boundary has been particularly stable since before 14 600 BP. The shuffling of plant communities caused by the relatively minor environmental changes have perhaps, been a positive force in recent speciation (Meadows and Sugden, 1989). In short, extinction processes have been kept in check by the relatively minor climatic changes during the Pleistocene. If climatic changes were more severe they would have resulted in an acceleration of extinction and subsequently a

smaller number of species in the fynbos. Herein lies a possible explanation why the fynbos has much greater species diversity than its ecological equivalents elsewhere in the world.

6.6 HUMAN INTERACTION IN THE KAROO AND CEDERBERG.

During the Pleistocene human populations became dispersed throughout southern Africa. Human activities have developed and compounded the effects of natural forces of change in ecosystems. The most significant of these have been the use of fire, with a documented occurrence of more than 100 000 years (Deacon *et al.*, 1988) and the farming practices of the last two thousand years.

The occurrence and location of people in southern Africa since the Last Glacial Maximum has been examined by Deacon (1974) using proxy evidence ie. radiocarbon dates. Deacon (1974) plotted the chronological frequency distribution of 223 radiocarbon dates on archaeological sites in southern Africa with a view to investigating their potential palaeoenvironmental significance. There are two pulses of high radiocarbon date frequency: one at the end of the Pleistocene and the other after 4 000 BP. In an update of the radiocarbon dated archaeological picture, Deacon and Thackeray (1984) show that there have been two phases of exponential population growth. These were from 15 000 BP to about 9 000 BP, being the earlier pulse, and the second initiated at about 4 000 BP. Meadows (1988a) shows that peat accumulation dates suggest moister phases which corroborate the findings of Deacon (1974). Palynological evidence from the Winterberg, Sneeuberg and Cederberg also suggest that moister conditions prevailed during these periods.

During the Last Glacial Maximum, conditions were colder and drier and the sea-level was about 120cm lower than the present (Deacon and Lancaster, 1988). The presence of large grazers in the fossil record (Deacon, 1976) suggests that conditions along the exposed continental shelf favoured the development of grasslands and was occupied by hunter-gatherers. As the continental shelf submerged (12 000 BP), more dates occur from the present coastal plains and hills, which were then occupied by the hunter-gatherers. The moister conditions of the Karoo uplands, which are evident in the pollen diagrams and the increase in burials and utensils (Parkington, 1986; Liengme, 1987; Hall and Binneman, unpublished) at these coastal sites suggests that the role of the rockshelters changed and indicate a more permanent existence at Elands Bay, Oakhurst and Matjies River at the beginning of the Holocene.

An hiatus of radiocarbon dated sites for the first half of the Holocene is then apparent. The implication is that warmer and drier conditions during the early and mid-Holocene (9 500 to 4 600 BP) made it unsuitable for hunter-gatherers to exploit the Karoo and grassland areas of the inland plateau. This caused a reduction in the population density, the number of occupied rockshelters and ultimately, the number of dated horizons.

The second pulse of dated sites occurs at about 4 000 BP, particularly from sites in the western Cape. Palynological and geomorphological evidence (Meadows, 1988a) from the Eastern Cape and Central Karoo indicate a moister period at about this time and this pulse may therefore be associated with climatic amelioration. The presence of hunter-gatherers is documented throughout the Karoo from this period onwards (Parkington, 1977; Hall, 1988; Sampson, 1986; Deacon, 1987). Deacon *et al.* (1978), Hall (1986) and Parkington (1986) provide good evidence for summer occupation of the rockshelters along the escarpment and fold mountains. During the winter months when plant foods were

less widely available there is evidence for occupation of coastal sites to exploit the marine resources (Deacon, 1983b; Parkington, 1986). This winter coastal occupation is supported by evidence from Elands Bay (Parkington, 1977, 1981), Nelson Bay Cave (Shackleton, 1973) and Boomplaas (Deacon, 1979). The comparison of potsherds, pottery and bulb remains from Melkhoutboom (Deacon, 1976), Windhoek Cave near Bredarsdorp (Grobelaar and Godwin, 1952) and De Hangen (Parkington and Poggenpoel, 1971) shows an overlap of evidence from these sites in the fold mountains. It has been speculated that there is probably an unbroken series of sites from the eastern Cape, westwards to Cape Town and then north as far as Clanwilliam, which were occupied during this moister period (Parkington and Poggenpoel, 1971).

The San hunter-gatherers who occupied the upland areas appear to have had a relatively small effect on the environment (Deacon, 1983b), but the introduction of herding animals some 1 800 years ago would have had a marked affect on grazing patterns and hence the vegetation. It is likely that the introduction of stock, particularly sheep, into the habitat where browsing game animals predominated would have had a marked effect on grazing (Klein, 1986). The rapid extinction of antelope in post-European times is seen by Klein (1972) as the result of a process of change which began over 1 000 years before the Europeans arrived in the southern Cape.

Stock were introduced to the coastal plains by Khoi herders about 1 800 years ago, as evidenced by paintings in many of the shelters (Deacon *et al.*, 1978; Hall, 1986; Parkington, 1986). In the eastern Cape, the hunter-gatherers seemed to have occupied the northern mountainous areas (Hall, 1986) while the Khoi herders occupied the coastal plains, using the sourveld grasslands for summer grazing. Hall (1986) observed that images of sheep are found predominantly within rock shelters situated on the coastal forelands, whereas no cattle are found in this region and are known only from the

region of the second escarpment. These seasonal grazers appear to show few signs of disturbance in the Ellerslie pollen diagram. It is not until the European settlers arrived in this area some four hundred years ago, that signs of disturbance due to overgrazing or mismanagement are evident. The increase in shrubby elements, particularly *Acacia karroo* and exotics (pines) are clear indicators of human disturbance during the historical past.

The introduction of Khoi herders, some 1 500 years ago, to the Sneeuberg and Nuweveldberg grasslands for summer grazing (Sampson, 1984b) seems to have little impact on the vegetation. The concentration of animals around natural springs and watering points is however, thought to have caused some disturbance. Merxmuellera Mountainveld does show a marked decline in the fossil pollen record during historical times and may be attributed to mismanagement and overgrazing of these sensitive Karoo grasslands by Trekboers and colonial farmers. The impact of Trekboers is marked on the Nuweveldberg pollen diagram, particularly the decline in grasslands, increase in disturbed Mountainveld, introduction of poplars and a higher incidence of fires.

In the Cederberg there is strong evidence of human-induced disturbance near the top of the deposits, which appears to have initially taken place prior to European occupation. According to Deacon (1983b) there is a long history of human settlement in the fynbos region and an equally long record of the uses of fires. An answer forthcoming from this study is that the Khoi-San had a slight impact on the vegetation as evidenced by the changing pollen frequencies and the reduction in a number of disturbance-sensitive taxa in the pollen record. There are also indications of changes in fynbos composition and fire history, culminating in the last hundred years or so.

Archaeological evidence is relatively abundant in the south-western Cape. San hunter-gatherers appear to have

ephemerally occupied rockshelters at the foothills of these mountains and concentrated in the main basin of the Olifants River during the dry season, particularly since about 4 000 BP. It is thought that during the winter they moved to the warmer coastal areas of Elands Bay (Parkington, 1977) and the impact of these hunter-gatherers would have been low in the upland mountainous areas which were only seasonally occupied (Deacon *et al.*, 1978). It is generally assumed that the caves and rockshelters of the mountainous areas were occupied by hunter-gatherers, while the Strandveld and coastal plains were occupied by the Khoi herders. The best documented evidence of stock in the western Cape archaeological sites are of sheep, which were introduced 1 800 years ago (Parkington, 1977). Cattle appear less often in rock paintings in the western Cape and were probably introduced slightly later than sheep (1 500 BP) (Manhire *et al.*, 1986). With the introduction of Khoi herders to the coastal plains, the San hunter-gatherers were being pushed into the mountainous areas of the escarpment. The increase in rock paintings of domestic stock during this period (1 500 BP) has been shown not only to be shamanistic in conception, but also the product of stressful conditions brought about by the increased competition with Khoi herders and immigrant groups (Manhire *et al.*, 1986). Fire abundance also appears to have increased during the past 1 000 years or so. The pollen diagrams from the Cederberg show a slight increase in a number of taxa which are associated with a disturbed habit (eg. Oxalidaceae, Montiniaceae, Plantaginaceae, *Stoebe*-type), or which perform well after fires. Although *Montinia* are not considered "weedy" in the fynbos, they are frequently found at or near the entrances to caves and are thus suggestive of areas that have been disturbed in the past. It seems likely that occupation by hunter-gatherers may have increased disturbance, possibly by adjusting the fire regime by patch-burning to enhance bulb growth, particularly of *Babiana, Gladiolus* and *Watsonia* in the mountainous area (Liengme, 1987). In addition, pastoralists are renowned for burning the vegetation to

encourage the growth of the young shoots most desirable for their animals. The result of this would not only cause increased disturbance, but would also include the movement of pastoralists over large areas of the coastal plains, in order for the quality of the grazing to be kept at a level sufficient for the long-term maintenance of their animals (Smith, 1986).

The introduction of Europeans to this area some 500 years ago (Penn, 1986) has had a major impact on the vegetation of the Cederberg, as evidenced by the marked changes in the pollen frequencies in the top 20cm of the sequence. The number of weedy taxa increase markedly and *Widdringtonia*, which had already declined, is almost eradicated. This disturbance is attributed principally to increased fire frequencies and the exploitation of the cedars and other natural resources by Colonial people (Manders, 1986).

6.7 REGIONAL PERSPECTIVE OF THE VEGETATION HISTORY.

The Late Quaternary environmental changes of the Karoo were complex and the tentative pattern which is emerging will need to be modified as further evidence accumulates. The Last Glacial Maximum at 18 000 BP is characterised, very broadly, by more arid, cooler climates (Tyson, 1986) across much of the subcontinent, but the late Pleistocene temperature rise was accompanied by complex shifts in the moisture conditions. Reconstruction of the vegetation history of the Karoo is hampered by the paucity of data. These four palynological investigations present evidence for the vegetation and environmental conditions prevailing at each of the upland areas, spanning varying time periods. The palynological data from the sensitive marginal or ecotonal Karoo areas provides evidence for the fluctuations in the extent of the Karoo Biome.

Analysis of the changes in Karoo environments requires careful consideration of the relationships between rainfall, runoff, vegetation cover, sediment yield and anthropogenic activities. The sensitivity of the Karoo to land-use mismanagement led Acocks (1953) to speculate about the relentless eastward march of the desert. The Karoo must, however, be viewed against a backdrop of repeated oscillations in the environment brought about by natural forces. Human activity is but one influence in the complex and interrelated dynamic system which is the contemporary Karoo of southern Africa.

The evidence from palynological data and peat accumulation dates (Meadows, 1988a) suggests a moister phase beginning, at some sites on the periphery of the Karoo, as early as 14 600 BP and at others as late as 9 000 BP. Holocene climatic changes are complex and it is relatively difficult to determine a general pattern. Palynological data, together with organic stratigraphic data indicate a moister period commencing between 5 000 and 3 500 BP (Bousman *et al.*, 1989). Human activity appears not to have significantly changed environmental conditions, but has significantly speeded up the degradation process (Partridge, 1988). This finding is contrary to the ideas put forward by Acocks (1953), who postulates that the eastward movement of the semi-arid elements is due primarily to human disturbance.

A vegetation history has been established for part of the Holocene from the eastern margin of the Karoo in the Winterberg mountains. The palynological evidence obtained by Meadows and Meadows (1988) augments the data from Ellerslie, providing evidence for the Late Pleistocene and Holocene period. Table 6.4 gives an outline of the vegetation and inferred environmental changes with the radiocarbon dates. The indications are that the Late Pleistocene was characterised by conditions cooler and drier than today with more xeric elements evident in the pollen

spectra. In the mid-Holocene, from 8 000 BP, Afomontane forest expanded somewhat as moisture and temperature conditions improved, but they never dominated the escarpment or plateaux in the area (Meadows and Meadows, 1988). The second half of the Holocene (4 200 BP) is characterised by a moister period, which fluctuates, becoming progressively drier and warmer with time.

Pollen zones	Radiocarbon date	Vegetation	Environ. conditions
Ec		Karroid shrubs &	
-		A. karroo increasing	Drier and Warmer
Eb		Grassland, expansion of forest patches	Moister
Eb		Karroid vegetation	Drier & Cooler
Ea	4 200 yrs BP	Moist open grassland	Moister & Warmer

Table 6.4 Summary of palaeoenvironmental interpretation of pollen spectra from the organic deposit on the Winterberg (Ellerslie).

The Aliwal North sequence (Coetzee, 1967) is from a site near the ecotone of the dry Karoo and moister *Cymbopogon-Themeda* grassland of the Basutolian Ecozone (Deacon and Lancaster, 1988). From about 13 000 to 9 000 BP pure grassland alternated with Karroid vegetation several times, indicating that cooler and moister, and warmer and drier intervals occurred. The north-eastern margin of the Karoo also appears to have been sensitive to the moister period of the terminal Pleistocene and the climatic oscillations which followed at the beginning of the Holocene.

The record of change at the Winterberg is broadly consistent with the evidence from Aliwal North (Coetzee, 1967) of an eastwards shift of the karroid vegetation during the late Quaternary, associated with cooler, rather than warmer conditions at the Winterberg (Meadows and Meadows, 1988). The Afromontane forest patches were probably reduced in size by more recent human activity and a greater fire frequency. The introduction of stock to this area some 1 000 years ago is evidenced by the paintings in rock shelters on the

Winterberg (Hall, 1986). The herders exploited the sourveld grasslands for summer grazing, but seem to have had little effect on the vegetation (Deacon, 1976). The effect of human activity, probably European settlers, is noted in the recent past. The upper parts of the diagram concur with the idea that Karroid elements have expanded in the past 500 years, particularly with regard to the spread of *Acacia karroo* into this area. These changes should be seen in light of the fact that Karroid elements had already disappeared from the Winterberg well before the arrival of European settlers. It would seem that fluctuations in the macro-climate of the region may have been more important vegetation determinants than either prehistoric San or European settlers.

Evidence for environmental fluctuations in the Central Karoo is hampered by the paucity of data and the relatively shallow or recent palynological records from the Compassberg and Nuweveldberg. Although the picture concerning moisture conditions for the terminal Pleistocene and earlier Holocene is still uncertain, it is more coherent for the first half of the Holocene and the archaeological hiatus in the interior around this time (Deacon, 1974), supports the idea of a drier period. Palynological evidence from Bousman *et al.* (1989) indicates shrubby xeric vegetation prevailing at Blydefontein at about 7 790 BP, which concurs with the idea of an arid interior at this time. During the second half of the Holocene the evidence from all over the Karoo supports

Pollen zones	Radiocarbon date	Vegetation	Environ. conditions
	present	Karroid Merx. Mountainveld	
		False Upper Karoo	Drier & Cooler
	3 590 yrs BP	Karroid Merx. mountainveld	Moister
		Grasslands	Moister

Table 6.5 Summary of the palaeoenvironmental interpretation of pollen spectra from the Sneeuberg (Compassberg).

the idea of increased moisture and a more effective vegetation cover (Deacon, 1974; Meadows, 1988a; Bousman *et al.*, 1989).

The evidence from Compassberg (Table 6.5), Alexandersfontein (Butzer, 1984a) and Blydefontein (Bousman *et al.*, 1989) show that these generally moister conditions were sporadically interrupted by periods of greater erosion and more marked climatic seasonality. The Merxmuellera grasslands of the upper plateau declines with time and Karroid shrubs of the False Upper Karoo spread onto the upland areas during the drier phases. Sampson (1985a) suggests that the San hunter-gatherers had little, if any, impact on the vegetation. However, evidence suggests that the Khoi pastoralists, who occupied the upland grasslands on a seasonal basis during the past 1 200 years, did cause a limited amount of disturbance, particularly during the drier periods and around watering points. The possibility that increasing human activity was, at least in part responsible for this, especially during the past few hundred years, is worth considering.

Pollen zones	Radiocarbon date	Vegetation	Environ. conditions
Nc		Merx. Mountainveld replaced by Karoo	Moist & Warm
Nb 1V		Karroid Brokenveld	Drier
Nb 111		Upper Karroid	Moister
Nb 11		Karroid Brokenveld	Drier
Nb 1			
Na	760 yrs BP	Merx. Mountainveld	Moister

Table 6.6 Summary of the palaeoenvironmental interpretation of pollen spectra from the Nuweveldberg. (Merx. = Merxmuellera).

Palynological data from the Nuweveldberg spans the last 760 years and provides evidence for vegetation fluctuations in the Central Karoo during this time (Table 6.6). The vegetation shifts are possibly associated with climatic oscillations, with human-induced changes being of secondary

importance except in the last few hundred years, where human disturbance by Dutch Trekboers is more marked. The onset of organic sedimentation 760 years ago coincides with other dates of peat initiation within southern Africa (Meadows, 1988a). The onset of sedimentation is associated with moister conditions than at present within the Karoo interior. It was followed by a drier phase and the increase in environmental disturbance due to the increased stresses of the Khoi herders and their reliance on the moister grasslands of the upper plateau for summer grazing. There are therefore, strong signs of human activity and disturbance within this time span, firstly by the Khoi herders and secondly by the Trekboer farmers. In both cases, the disturbance was sufficient to affect the vegetation, but in neither instances were the geomorphological thresholds of the vlei exceeded.

Environmental fluctuations on the western margin of the Karoo are extrapolated from palynological evidence obtained from the Cederberg. The expansion of the Karroid vegetation in a south-westerly direction at any time during the Late Pleistocene and Holocene would be reflected in these palynological records. Although environmental fluctuations

Pollen zone	Radiocarbon date	Vegetation	Environ. conditions
Df		Restioid Fynbos	Present conditions
De IV		Ericaceous Fynbos	Ameliorating
De III		Undifferentiated Fynbos	Dry
De II		Ericaceous Fynbos	Ameliorating
De I	3 230 yrs BP	Drier Ericaceous Fynbos	Dry
Dd		Restioid Fynbos/ Proteoid Overstorey	Moist
Dc III		Ericaceous Fynbos	Ameliorating
Dc II	10 090 yrs BP	Cedars with Ericaceous Understorey	
Dc I		Cedars with Ericaceous & Proteoid Understorey	
Db		Proteoid Fynbos	Dry
Da	14 600 yrs BP	Restioid Fynbos	Moist

Table 6.7 Summary of palaeoenvironmental interpretation of pollen spectra from the Cederberg, Driehoek Vlei.

Pollen zone	Radiocarbon date	Vegetation	Environ. conditions
Se		Restioid Fynbos	Present
Sd 11	1 990 yrs BP	Ericaceous Fynbos	Mesic
Sd 1	3 310 yrs BP	Transitional Ericaceous Fynbos	Amelioration
Sc		Undifferentiated Fynbos	Drier
Sb 111		Ericaceous Fynbos	Mesic, Subhumid
Sb 11		Cedars with Ericaceous Understorey	Amelioration
Sb 1		Cedars with Ericaceous & Proteoid Fynbos	-
Sa	9 600 yrs BP	Proteoid Fynbos & Restioid understorey	Moister

Table 6.8 Summary of palaeoenvironmental interpretation of pollen spectra from the Cederberg, Sneeuberg Vlei.

have occurred, the Late Pleistocene and early Holocene climates appear to have remained broadly uniform and the underlying geology seems to be of primary importance in maintaining the vegetation boundary.

Tables 6.7 and 6.8 indicate that the fynbos plant communities on the Cederberg have been altered in composition in response to climatic oscillations over the past 15 000 years, but at no time has the Karoo-fynbos boundary shifted. This emphasises the point made by Avery (1983) that the Fynbos Biome is an environmentally and ecologically complex one. There is good evidence for optimal temperature conditions during the early to mid-Holocene elsewhere in the winter rainfall region which are not reflected in the Cederberg and therefore changes at one location may not occur throughout the biome. It may also be that the fynbos vegetation is not particularly responsive to precipitation changes and the existence of a strong geological-vegetation gradient in the region would support this, ie. substrate is more important than climate in determining community composition.

According to Deacon and Lancaster (1988) the period between the end of the Last Glacial Maximum and the beginning of the Holocene displays dramatic changes in the biological data which is related to the sudden rise in global temperatures and the adjustment of plant and animal communities. This shift is thought to be more dramatic in the Cape Ecozone than elsewhere in southern Africa and was initiated before 14 000 BP (Deacon and Lancaster, 1988), as indicated by the onset of organic sedimentation at Driehoek Vlei. The subtle shifts in communities within the Mountain Fynbos during the Holocene concur with the fluctuations in relative precipitation presented by Scholtz (1987b), but the altitude of these sites in the Cederberg has an ameliorating influence. The arid phase of the mid-Holocene in the Central Karoo appears to have been widespread and also influenced the south-western Cape (Scholtz, 1987a; Avery, 1982). The climatic fluctuations of the second half of the Holocene appear to be less severe than those of the Pleistocene and the prevalence of moister conditions.

The vegetation history of the Karoo Biome therefore, shows that climatic fluctuations have occurred throughout the last 15 000 years. The terminal Pleistocene is characterised by a moister period when grasslands and forests expanded, thus causing a slight retreat of the eastern, northern and southern margins of the Karoo, whereas the mid-Holocene (c.6 000 BP) is characterised by an arid phase and an associated eastward movement of the Karroid elements and expansion of the Karoo. During the late Holocene (c.4 000 BP) there is a return of the mesic conditions and a slight contraction of the Karoo margin. At the present time the Karoo interior is experiencing slightly drier and warmer conditions, thus causing an associated expansion and eastward movement of the Karoo margins. Although the western margins of the Karoo are affected by these climatic fluctuations, the associated shift of the vegetation is controlled by the geological boundary. Human activity appears not to have significantly affected vegetation

conditions until the past few hundred years. Since the arrival of European settlers, the natural environmental fluctuations have been significantly "accelerated", in some cases causing irreversible damage, particularly in the sensitive Karroid environments.

CHAPTER 7

CONCLUSION

The worldwide cycle of glacial and interglacial events of the Late Quaternary caused a number of significant palaeoenvironmental adjustments (Deacon and Lancaster, 1988), which have been a pervasive factor in the nature and distribution of the present day vegetation communities of southern Africa. Consequently, the contemporary vegetation pattern must be interpreted against a backdrop of environmental changes coupled with the effects of human activity. It is therefore, important to gain an understanding of these variations to more effectively manage the contemporary environment. Acocks (1953) was aware of this need and went so far as to speculate about the vegetation distribution patterns in South Africa, both in the past and future. Ecologists have recognised that an understanding of the past is an essential key to the explanation of the present, and by implication, the future.

The general aim of this study was to establish a late Quaternary palaeoenvironmental history of the Karoo using palynological investigations of upland vlei deposits. The data have shown that the late Quaternary environmental changes in the Karoo Biome have been complex and that the paucity of data for this expanse of semi-arid terrain has hindered a detailed reconstruction of the palaeoenvironmental history. A tentative pattern of change has emerged from these investigations, but will require modification as more data becomes available from the Karoo plains between these mountainous areas. It would be a mistake to assume that vegetation changes occurred over wide regions and were irreversible. Rather, these changes may have occurred several times in different regions and at

different tempos, whereas still other regions probably functioned as refugia. All these factors, at present still indiscernible in the fossil record, greatly affect the distribution of vegetation in space and time. The problems of interpretation of pollen data in southern Africa are many and well known (Scott, 1984) and, as a result few studies have reached definitive conclusions. It is for this reason that only tentative ideas of patterns of change are presented for the Karoo Biome.

A number of objectives are listed in Chapter One, all of which have been suitably met within the limits of this palynological investigation. The objectives or questions posed include the following:

- To construct a pollen reference collection of the contemporary pollen-producing species of the Karoo.
- How closely is the modern pollen rain related to the vegetation pattern in the Karoo and Fynbos regions ?
- Is it possible to infer vegetation changes from the pollen spectra using numerical techniques and which of these are the most suitable ?
- How has the vegetation of the Karoo changed during the Late Pleistocene and Holocene period ?
- What are the factors responsible for these changes ?
- Has man played a role in changing the vegetation ?

Additional questions have been posed as a result of findings in this study:

- Are the margins of the Karoo, particularly the eastern margin, stable, fluctuating or spreading as suggested by Acocks (1953) ?
- What influence have the climatic fluctuations of the late Pleistocene and Holocene had on the Fynbos species richness ?
- Is this study significant in the broader context of management of the natural environment ?

7.1 POLLEN REFERENCE COLLECTION.

The pollen reference collection contains slides of the contemporary pollen-producing species from an extensive area, including the southeastern Cape or Winterberg region, the Sneeuberg and Nuweveldberg of the Central Karoo, the Tanqua and Succulent Karoo and the Mountain Fynbos. The expansion of the reference collection is an ongoing project and, to date, there are a total of 3 501 different species on slide, of which 1 468 have been photographed to form a photograph reference collection. The collection forms a vital, basic component of this palynological investigation and, without it, few positive identifications could have been made. It is hoped that this collection will expand to include the rest of the Fynbos Flora.

7.2 CONTEMPORARY POLLEN STUDIES.

The climatic changes of the Late Quaternary and Holocene have been a major controlling force causing changes in vegetation of the Karoo. Without recourse to evidence from the past, it is difficult to understand the contemporary spatial distribution patterns of vegetation assemblages. The fossil record is severely limited, which constrains the nature and scope of data investigated in palaeoecology. Within these constraints the exploitation of the fossil record to gain information about the morphology, taxonomy, geographical distribution of organisms, climate and the functional relationship between these are necessary. The modern pollen rain and its characteristics need to be fully understood in similar terms as the fossil pollen material, because without an understanding of how the present vegetation reacts to changes, inferences cannot be made about the past.

The extensive contemporary pollen rain investigation was undertaken to establish the existence of the vegetation-

pollen relationship and to establish how closely the modern pollen rain relates to the vegetation pattern in the Karoo and Mountain Fynbos. The general trends of pollen production in the Karoo show that Poaceae and Asteraceae are the dominant pollen-producers. The contribution of Poaceae pollen is greatest in the eastern margin of the Karoo (Winterberg) and declines substantially as one progresses west into the Fynbos Biome, where Restionaceae is the dominant pollen-producer. Asteraceae pollen frequencies are low in the eastern Karoo, but increase substantially in the central and western Karoo and Cederberg region. The arboreal element, which contributes substantially to the modern pollen spectrum of the Winterberg, decreases to negligible frequencies in the Central Karoo but increases to about 5% in the Mountain Fynbos, as indeed is the case within the regional vegetation. There is therefore, conclusive evidence of a close and direct association between the pollen rain characteristics and the vegetation which produces the pollen.

Pollen traps and surface samples from within the vleis provide a good indication of the regional vegetation cover. As a consequence, the fossil pollen spectra are expected to yield a sound indication of the former regional patterns. The pollen trap spectra, particularly those at 1m above the ground, are more representative of the regional vegetation than the surface sample spectra in both the Karoo and Fynbos Biomes. The difference in representivity of the surface sample spectra and the pollen trap spectra in the Fynbos Biome is due to the life-forms and stratified structure of the vegetation and not due to preservation anomalies, as is the case in surface samples from the dry Karoo soils.

An observation which emerges from the examination of pollen trap and surface sample spectra is that vlei elements are over-represented and arboreal elements under-represented within the surface sample spectra, making pollen trap data more reliable as modern pollen analogues. On a year to year

basis the surface sample pollen spectra also vary more than the pollen trap spectra. Replication over a number of seasons is therefore necessary to improve the representivity of the contemporary pollen data.

The fynbos vegetation has a number of entomophilous taxa, for example Proteaceae and Ericaceae, which are usually under-represented within the pollen spectra. This reduces the representivity of the pollen spectra from the fynbos. The differential productivity and dispersal ability of these taxa needs to be taken into account when interpreting this palynological data. The overall results suggest that the contemporary pollen rain is a fair reflection of the vegetation communities which produce it. This conclusion is echoed by others in this field (Flenley, 1973; Hamilton and Perrott, 1980; Scott, 1984; Meadows, 1984a; Meadows and Meadows, 1988). The modern pollen spectra, particularly those from the central Karoo, proved to be reliable data bases from which modern analogues are derived from the statistical analyses.

7.3 STATISTICAL MANIPULATION OF FOSSIL POLLEN DATA.

Palynological evidence from the four upland sites (Winterberg, Sneeuberg, Nuweveldberg and Cederberg) was used to reconstruct the Quaternary palaeoenvironments of the Karoo. The use of numerical techniques to infer vegetation changes from palynological data is widely accepted, but varies according to the data set and the problem being addressed. With the aid of multiple discriminant analysis and TWISA, the complex palynological records have been manipulated and provide a vegetation history of varying time spans for each of the upland areas of the Karoo. Multiple discriminant analysis, which compares fossil pollen assemblages with modern pollen spectra, is used to aid in the palaeovegetational reconstruction. Since Holocene vegetational changes usually involve temporal changes from

one vegetation to another, discriminant analysis is an effective means of depicting major trends of vegetational changes from pollen-stratigraphic data. This technique is found to be useful in determining whether modern analogues exist for the fossil pollen assemblages and considerably enhances interpretation of the fossil pollen spectra.

Discriminant analysis identified relatively minor shifts in vegetation assemblages in both the Nuweveldberg and Cederberg cores, which were not apparent by visual investigation. The vegetation assemblage identified as "cedars with an ericaceous understorey", which occurred on the Cederberg about 10 000 BP, is found to have a modern analogue different to that which prevailed at the beginning of the Holocene ie. it has no real modern analogue. The modern analogue for this vegetation assemblage is depicted by an exceptionally sparse canopy cover of *Widdringtonia cedarbergensis*, as no dense cedar stands are found on the Cederberg today. This confirms the idea put forward by Manders (1986), that the cedar trees have declined dramatically in this area. The pollen data hints however, that the ecological situation of *Widdringtonia cedarbergensis* had been stressed for some time prior to the arrival of Europeans in the region, thus their demise may not be due entirely to over-exploitation..

TWISA, an objective ordination technique, confirms the subjective grouping or zonation of vegetation assemblages and produces a classification with a similar array of former vegetation types, but in a slightly simpler zonation format. Discriminant analysis, which is usually most effective for larger scale vegetation changes (Liu and Lam, 1985), proved to be a valuable tool for identifying vegetation changes from palynological data. It is particularly useful for identifying ecotonal areas and relatively minor shifts in vegetation assemblages in the Nuweveldberg and Cederberg regions during the late Pleistocene and Holocene period.

7.4 VEGETATION CHANGE IN THE KAROO.

The examination of how the Karoo vegetation has changed during the Late Pleistocene and Holocene and the factors responsible for these changes forms the central focus of the palynological investigation. The vegetation changes which are implied by the changing pollen frequencies in each area, the palaeoclimatic implications thereof and the radiocarbon dates are used to produce an effective moisture curve (Figure 7.1). This summarises the climatic fluctuations, in particular the moisture regime, within the Karoo and Fynbos Biomes during the late Pleistocene and Holocene period.

The vegetation history of the Karoo Biome shows that climatic fluctuations have occurred throughout the last 15 000 years. The terminal Pleistocene (16 000 to 10 000 BP) is characterised by a moister phase, during which, it is documented that organic sedimentation began and grasslands and forests expanded. This caused an associated retreat of the eastern, northern and southern margin of the semi-arid Karroid vegetation. The winter rainfall region is characterised by an increase in woodland taxa and the onset of sedimentation in the Cederberg, which suggests higher effective precipitation. The mid-Holocene (c.6 000 BP) is characterised by an arid phase and an associated eastward movement of the Karroid elements and expansion of the Karoo. Vogel (1982) presents evidence which indicates two relatively moist phases of differing nature - the first dating between 7 700 and 6 300 BP which did not support as complete a vegetation cover as that which developed during the second phase (3 600 to 1 300 BP) which resulted in extensive soil formation. During the second half of the Holocene a number of smaller fluctuations in environmental conditions have occurred in the Karoo and Fynbos Biomes. During the last 4 000 years, there has been return of the mesic conditions as evidenced by the onset of organic sedimentation at numerous sites (Winterberg and Compassberg) as well as palynological data, causing an associated

contraction of the Karoo margin. At the present time the Karoo interior is experiencing slightly drier and warmer conditions, causing an associated expansion and eastward shift of the Karroid elements and Karoo margins. Although the western margin of the Karoo is affected by these climatic fluctuations it is not expressed by the movement of the vegetation assemblages, because the fynbos vegetation distribution is controlled primarily by the geological boundary. These findings show that the Karroid vegetation has fluctuated in response to climatic oscillations of the late Pleistocene and Holocene period.

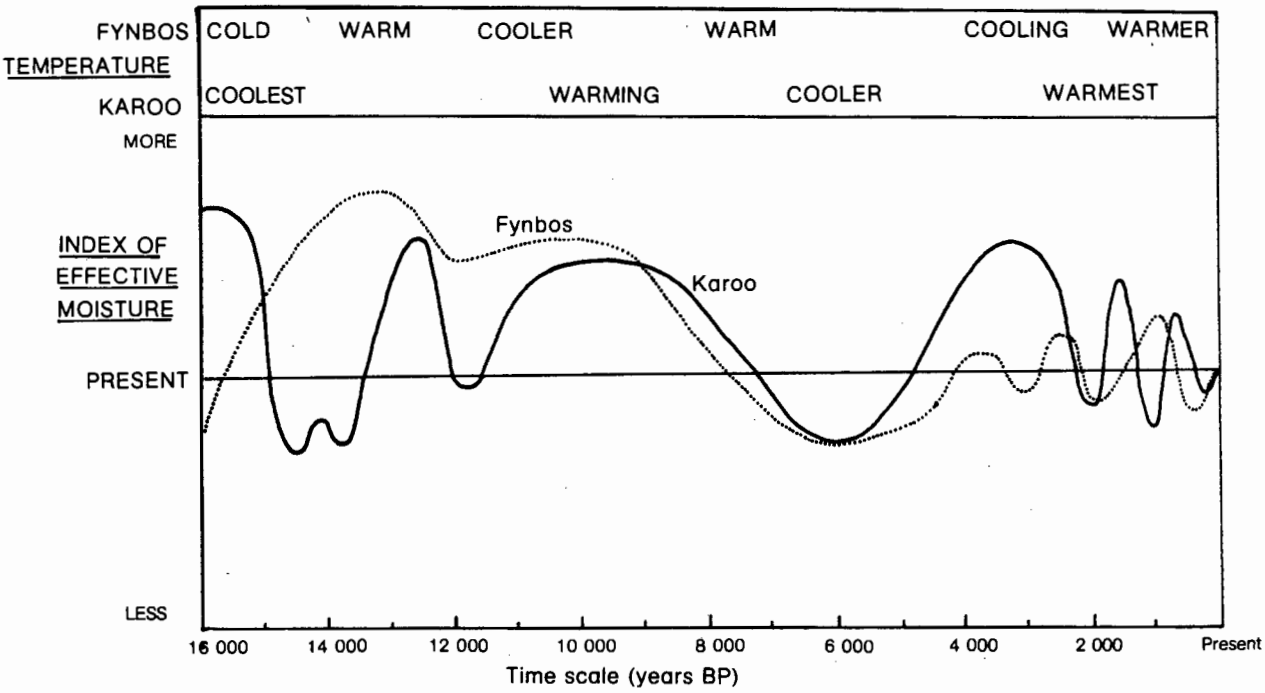

Figure 7.1 A relative effective moisture curve of the last 16 000 years for the Karoo and Fynbos Biomes (Adapted from Scholtz, 1987a; Meadows and Sugden, 1988)

The relatively small variation within the pollen diagrams from the Cederberg, in the Fynbos Biome is an anomaly, as they indicate no marked changes in the Mountain Fynbos over the last 14 600 years and most diagrams of this sort of time span show prominent fluctuations. It is for this reason that the influence of these minor climatic fluctuations on the fynbos species richness is questioned. The conclusion that this part of the Fynbos Biome experienced relatively

little environmental change in the late Pleistocene and Holocene is unexpected since elsewhere in the sub-continent there have been frequent climatic changes. Although fluctuations in climate have occurred, the Mountain Fynbos has remained *in situ* since before 14 600 BP. The shuffling of different sclerophyllous plant communities, caused by the relatively minor environmental changes, have been a positive force in recent speciation, ie. extinction processes have been kept in check by the relatively minor climatic fluctuations during the late Pleistocene. The fact that the fynbos plant communities on the Cederberg have been altered in composition over the last 14 600 years without ever being severely stressed and hence removed, is a potential contributing factor in the speciation processes in the fynbos.

7.5 HUMAN INFLUENCE ON VEGETATION CHANGE.

Much has been written about the disturbed state of the flora and fauna of the Karoo and Fynbos regions that has been caused by human activity (Moll, 1982). Palynological investigations are a useful and appropriate means of testing these statements and seeing whether people have played a major role in changing the vegetation.

During the last 100 000 years, the influence of humans via veld management practices involving fire has helped to shape the present vegetation (Deacon, 1983a). This influence has been progressive, culminating in the historic period (post-1652) with the catastrophic impact of European settlement. Even by the seventeenth century, the biota had been modified to some extent by the 2 000 year occupation by indigenous pastoralists and a far longer occupation by hunter-gatherers (Hendey, 1983). The latter disturb ecosystems through their use of fire that, whether by accident or design, adds to the natural fire frequency and so affects the character of the local vegetation. In addition, hunter-gatherers have exploited some of their preferred plant and animal foods and

thus may have contributed to the decline or extinction of species that were already stressed. The situation in respect of prehistoric pastoralists is less equivocal but they undoubtedly had a detrimental effect on the vegetation. They are known to have used fire to promote the growth of grass for the stock (Skead, 1980), an activity that is detrimental to shrubs and trees. Thus, two key factors in modern agricultural mismanagement, fires and overstocking, were manifested in this region in prehistoric times (Hendey, 1983).

Palynological evidence shows that fluctuations in the vegetation assemblages occurred prior to the establishment of Khoi herders and European settlers. This suggests that climatic fluctuations, particularly moisture and temperature, are the major forces responsible for large-scale natural vegetation changes of the Late Quaternary. Human activity does not appear to have profoundly affected the vegetation conditions until the past few hundred years. Since the arrival of European settlers, the natural environmental fluctuations have been significantly accelerated or amplified and some parts of the Karoo have already been irreversibly damaged. So much topsoil has been lost that pedogenesis would have to go full cycle before the vegetation that previously occurred could re-establish; this is unlikely as all soil-stored seeds have been destroyed (Hilton-Taylor and Moll, 1986).

Acocks (1953) provided a model map of the vegetation of South Africa prior to European expansion, that serves to emphasise the dramatic changes that have taken place with the introduction of agriculture and permanent settlement. As Deacon (1983b) suggests, this model is a challenge to palaeoecologists to obtain more direct information on the evolution of ecosystems, in particular the Karoo and Fynbos Biomes. With this in mind, the question of whether the margins of the Karoo are stable, fluctuating or spreading as suggested by Acocks is addressed. Acocks (1953) predicted

an eastward spread of the Karoo vegetation, purportedly under the influence of inappropriate land management. The decline in grasslands, the increase in Karoo scrub and invasion of *Acacia karroo* is indeed apparent in the palynological data from the Nuweveldberg, Compassberg and Winterberg on the eastern margin of the Karoo. The general climatic trend at the present time, as indicated in Figure 7.1, is one of a drier phase and thus one would expect the expansion of the Karoo. This has however been accelerated by overgrazing and disturbance. The sensitivity of the Karoo to mismanagement, which led Acocks to speculate about the relentless eastward march of desert and Karoo must therefore, be viewed against a backdrop of repeated oscillations in the environment, which have been brought about by natural causes, as described in the previous section. The denudation of the Karoo in the recent past may be explained then by both the fragility of the ecosystem and the long history of livestock overgrazing.

The final question addressed is the relevance of this study in the broader context of management of the natural environment. It is clear that a general understanding of how the Karoo vegetation has fluctuated in response to environmental changes is necessary so that the contemporary natural environments may be more effectively and appropriately managed. This understanding is essential for the prediction and modeling of future environmental changes, in particular, the predicted $3^{0}C$ increase in global temperatures within the next twenty to fifty years as a result of the Greenhouse Effect (MacDonald, 1989). The need to predict future changes from inferences from the past is becoming more important. As expressed by MacDonald (1989, p.3) "scientists in the southern hemisphere have a crucial role to play in ensuring that the IGBP meets its ambitious overall objective of providing an accurate predictive understanding of the total Earth system by the end of the century".

7.6 RECOMMENDATIONS.

Within the limits of this palynological investigation it is not possible to obtain sufficient evidence to provide a firm and detailed reconstruction of the past vegetation types and climates of the whole of the Karoo. The investigation focused on sites along a west-east transect of the Karoo. The vegetation and climatic oscillations on the southern margins (Swartberg and Suurberg Mountains) and northern ecotones of the Karoo still need to be investigated to give a more holistic view. Regional clues and evidence have been obtained to produce a tentative picture of the Holocene vegetation changes within the Karoo Biome and marginal areas.

The search for deep vleis or organic deposits extending back to the beginning of the Holocene, from the Karoo plains between the mountainous areas, is still required to augment the evidence already obtained. It is necessary to know whether the vegetation on the plains responded to climatic fluctuations in the same way as that of the upland areas. At the present stage, undue weight has to be given to those few, better studied localities that are widely separated in time and space. As has been pointed out by Truswell and Harris (1982) in a similar study in Australia, the generalisations from such varied and isolated data must be made with caution.

Contemporary pollen studies have been undertaken at each of the study areas. A larger scale study of contemporary pollen investigation of the major vegetation assemblages throughout the Karoo is necessary so that the fossil pollen analyses can be placed in the broader context of modern Karoo and associated plant communities. As Meadows (1985a) points out, it is difficult to assess the representivity of southern African pollen on the basis of such a few studies over such a huge area. Replication of this type of data over a five-year period to eliminate the variation from one

year to the next is needed, so that reliable contemporary palynological data, which can be used as modern analogues in statistical manipulations, is available.

Another feature which became apparent during this study is the lack of pollen atlases for the southern African flora. Although the few palynologists of this country all have their own regional pollen collections, there is no central collection for the Flora of Southern Africa. Greater co-operation and exchanging of slides is necessary so that the regional collections can expand to cover a greater part of the country. As the need increases, it is hoped that the present pollen reference collection can be expanded and made more accessible to other palynologists in the form of a pollen atlas.

Within the fossil investigations, not enough dated palaeoclimatic sequences are known for the late Pleistocene and Holocene. Vlei sites in the Cederberg proved to be fruitful in establishing a late Pleistocene and Holocene vegetation history of the area. There are, however, numerous sites of deposition which still have to be analysed. Some of these have been briefly examined and samples extracted for preliminary pollen analysis. Particularly promising are the shallow vleis on the top of Table Mountain, the coastal dune-slack peats of the southern Cape Peninsula (Agar, 1988), the Cecelia cave sediments on Table Mountain presently being investigated by A. Baxter at the University of Cape Town and the clastic sediments of Verlorenvlei. The potential for sites in the south-western Cape is much greater than might be expected, although many of these sequences may be chronologically stunted. Palynological sequences extending back to the Last Glacial Maximum are essential for comparative purposes, to substantiate the present findings from the Cederberg and to see whether the minor shifts or shuffling of sclerophyllous vegetation communities of the Mountain Fynbos occurred elsewhere in the south-western Cape.

Future research should aim at enlarging the palaeoenvironmental data base and extend modern studies to provide analogues of plant and animal distributions, and the climatic conditions that affect sedimentary sequences. Multidisciplinary biogeographic investigations, in which environmental changes from a number of different lines of evidence, ie. palynological, geomorphological, geological and archaeological, should be integrated to give complementary evidence and a broader idea of environmental fluctuations. Any change in the length of the growing season, season of precipitation, soil moisture content or other ecophysiological factors affect plant species differentially. They will also alter their interaction with animals serving as pollinators, with seed dispersal agents and with herbivores and, in turn, predators. In this way, dynamic changes in biotic communities over time can be reflected in the fossil record and without a multidisciplinary approach, the fossil record would be exceptionally difficult to interpret.

This research has shown that environmental fluctuations occur continually and vegetation distributions adjust to these changing conditions. During the last 2 000 years and particularly since the advent of European colonists, the natural communities have been considerably modified by changing land-use patterns. These agricultural and settlement patterns have lowered the diversity of ecosystems and have reduced their resilience, simulating conditions more similar to the Last Glacial Maximum than the late Holocene. This loss of diversity through extinction or range restriction of taxa is serious, because it implies that as southern Africa progresses into the next century with the bleak predictions of change associated with the "Greenhouse Effect", the vegetation communities will be impoverished to an even greater extent. The goals of conservation and management should therefore be directed at maintaining diversity, restoring the natural range of taxa and at reducing the risk of loss of endangered species.

There is therefore, a need to invest research resources into historical studies so as to improve our understanding of how the vegetation has responded to change in the past.

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APPENDIX

APPENDIX A.

PREPARATION PROCEDURE FOR POLLEN REFERENCE SLIDES.

1. Place anthers or flower buds into 50ml glass centrifuge tubes.
2. Add 30 ml 10% NaOH and stir.
3. Place in boiling water bath for 5 minutes, stirring often.
4. Filter through a clean 150 micrometre mesh sieve into a 100ml glass beaker. Lightly crush the material on the screen and wash through with distilled water.
5. Centrifuge at 2 000 r.p.m. for 1 minute and decant supernatant (HERMLE-Z320 Centrifuge).
6. Transfer organic sediment to 10ml glass centrifuge tubes using glacial acetic acid.
7. Stir, centrifuge at 3 600 r.p.m. for 3 minutes and decant.
8. Add acetolysis mixture. Stir and place in boiling water bath for 3 minutes.
   Acetolysis mixture : Mix 90ml (9 parts) acetic anhydride and 10ml (10 parts) concentrated sulphuric acid in dry measuring cylinder.
9. Centrifuge and decant.
10. Add 7ml glacial acetic acid. Centrifuge and decant.
11. Wash three times with distilled water. In the final wash, add 1 drop aqueous safranine.
12. Centrifuge and decant.
13. Invert tubes onto blotting paper, if method A is to be used for mounting.

MOUNTING SLIDES - METHOD A.

1. Clean and label slides (5 slides made of each pollen specimen).

2. Heat paraffin wax until it melts.
3. Cut small cubes of glycerine jelly, place on tip of dissecting needle and wipe around the sides of the centrifuge tube to pick up pollen.
4. Place jelly on centre of the slide and pass slide over heat to melt jelly. Caution : do not let it boil or get too hot as it damages the pollen.
5. Dip warmed glass rod into paraffin wax, a strip of which is applied to the slide, around the jelly.
6. A coverslip is laid over the jelly so that it touches both the jelly and the wax - this prevents bubbles forming. The coverslip is gently lowered onto the hot jelly using a dissecting needle.
7. The entire area under the coverslip may be briefly warmed to re-melt the paraffin wax and induce sealing of the preparation.
8. Scrape off any excess paraffin wax.

POLLEN MOUNTING - METHOD B.

1. The same chemical preparation is followed until the final wash in distilled water (step 10).
2. This is followed by adding 5ml Tertiary Butyl Alcohol (TBA). Centrifuge and decant.
3. Clean and label slides (5 slides made of each pollen specimen).
4. Using a clean micropipette or pasteur pipette, 2 drops of the pollen - TBA suspension are mounted onto the centre of the slide.
5. The excess TBA is allowed to evaporate for $\pm$1 minute.
6. Two drops of DPX mountant are applied to the residual pollen on the slide.
7. A coverslip is laid over the DPX mountant, using a dissecting needle to lower the coverslip, to prevent bubbles forming.
8. Allow the slide to dry before filing. While drying, place the slide upside down on a test tube rack or Carlton towel. This allows the heavy pollen grains to

float to the top of the slide before the DPX mountant solidifies.

APPENDIX B.

PREPARATION TECHNIQUE FOR SURFACE SOIL SAMPLES.

1. Place 5 grams of soil sample into a 50ml glass centrifuge tube.
2. Add 20ml 10% NaOH and place in water bath, set at $90^{o}C$ for 5 minutes.
3. Strain and wash thoroughly through a 150 micrometre sieve, using distilled water.
4. Centrifuge filtrate and decant supernatant. All centrifuging, from this step onwards, is done at 3 600 r.p.m. for three minutes.
5. Wash five times with distilled water or until the supernatant becomes clear.
6. Wash with 20ml 10% HCl. Centrifuge and decant.
7. Transfer to 50ml plastic centrifuge tubes.
8. In the fume cupboard, treat with 20ml 40% hydrofluoric acid (HF) for at least three hours, in pre-set, heated waterbath. Stir occasionally.
9. Stir, centrifuge and decant (place caps on the centrifuge tubes while centrifuging).
10. Decant sample into 10ml glass centrifuge tubes using 10% HCl. Place in the water bath for 20 minutes.
11. Centrifuge and decant.
12. Wash with distilled water, centrifuge and decant.
13. Add 7ml glacial acetic acid. Stir, centrifuge and decant.
14. Add acetolysis mixture to each tube and place in heated waterbath ($90^{o}C$) for 3 minutes.
    Acetolysis mixture : Mix 9 parts (9ml) acetic anhydride and 1 part (1ml) concentrated sulphuric acid.
15. Stir, centrifuge and decant.

16. Add glacial acetic acid, centrifuge and decant.
17. Add 9 ml distilled water and 1ml NaOH to obtain a pH of 7.0. Stir, centrifuge and decant.
18. Wash with distilled water three times.
19 For the last wash, add two drops aqueous safranine. Stir, centrifuge and decant.
20. Add 7ml TBA. Stir, centrifuge and decant.
21. Transfer suspension into labelled vials using TBA. Centrifuge and decant.
22. Add silicone oil (Merck, Art.7742 for oil immersion), equal in amount to pollen sediment.
Store uncapped for 24 hours to allow TBA to evaporate.

MOUNTING.

23. Stir polleniferous silicone oil, using a clean toothpick, until the pollen is evenly suspended. Alternatively, the solution may be mixed using a magnetic stirrer.
24. Two drops of the polleniferous oil are mounted using a pasteur pipette.
25. Relative pollen counts are made. A minimum of 400 pollen grains are counted per sample, thus getting a representative sample.

APPENDIX C.

PREPARATION PROCEDURE FOR POLLEN TRAP MATERIAL.

1. The acetate fibre is removed from the pollen trap and dried at 105 ^{o}C for 1 hour.
2. The sample is left soaking overnight in acetone, sufficient to cover the sample.
3. The mixture is stirred thoroughly.
4. Decant into 50ml centrifuge tubes. All residual material must be washed into the tubes with fresh acetone.

5. Tubes are centrifuged for three minutes at 3 600 r.p.m. and the supernatant decanted. All centrifuging in the following steps is done at this speed and for three minutes.
6. Sediment in the bottom of the tubes is washed into the beaker and thoroughly rinsed with acetone.
7. The sediment is then passed through a 150 micrometre mesh sieve to remove coarse material.
8. The filtrate is washed in acetone, centrifuged and decanted.
9. The acetone is evaporated off by placing the centrifuge tubes in the water bath at 90^{0}C for 20 minutes.
10. Add 25ml 10% NaOH and place in the water bath for 20 minutes.
11. Centrifuge and decant.
12. Add 25ml 40% HF, stir and place in the pre-set water bath for at least one hour.
13. The sample is centrifuged and the supernatant decanted. (Caps should be placed on the tubes for centrifuging).
14. Decant sample into 10ml glass centrifuge tubes using 10% HCl. Centrifuge and decant.
15. Wash with 5ml glacial acetic acid, centrifuge and decant.
16. Acetolysis is then conducted as for fossil samples. (Mix 90ml (9 parts) acetic anhydride and 10ml (1 part) concentrated sulphuric acid in a dry measuring cylinder and add 5ml to each sample.)
17. Stir and place in water bath ($\pm$ 70^{0}C) for 2-5 minutes.
18. Centrifuge and decant.
19. Add 5ml glacial acetic acid, centrifuge for 5 minutes at 3 600 r.p.m. and decant.
20. Wash with distilled water, centrifuge and decant.
21. Add distilled water and 1 drop aqueous safranine.
22. Stir, centrifuge and decant.
23. While centrifuging, prepare vials and dissolve Tertiary Butyl Alcohol (TBA) in hot water.
24. Add 5ml TBA, centrifuge and decant.
25. Transfer suspension to small glass vials using TBA,

centrifuge and decant.

26. Add 2 drops silicone oil and store uncapped for 24 hours to allow excess alcohol to evaporate.

MOUNTING.

27. Stir polleniferous silicone oil, using a clean toothpick, until pollen is evenly suspended.
28. Mount 2 drops of polleniferous oil.
29. Relative pollen counts are done. A minimum of 400 pollen grains are counted per sample.

APPENDIX D.

FOSSIL POLLEN PREPARATION TECHNIQUE.

Note : Pre-set the water bath to $\pm$ 90 ^{o}C.
50ml glass centrifuge tubes are used in the initial stages.
Label all tubes well and keep in sequence throughout process to avoid muddling.
Peat samples in vials should be stored in the refrigerator and returned immediately after sub-sampling.
All centrifuging should be done at 3 600 r.p.m. for 3 minutes, unless otherwise stipulated.

1. Place 5g of each organic soil sample (peat) into a 50ml glass centrifuge tube. If the mud is wet or pollen-rich, flame the spatula between each transfer.
2. Add 20ml 10% NaOH and place in water bath, set at 70^{o}C, for 5 minutes, stirring occasionally.
3. Strain and wash thoroughly through a 150 micrometre sieve.
4. Centrifuge and decant.
5. Wash five times with distilled water or until the supernatant becomes clear.

6. Wash with 10% HCl, centrifuge and decant.
7. Transfer suspension to 50ml plastic centrifuge tubes using HCl.
8. In fume cupboard, treat with 40% HF for at least 3 hours in pre-set water bath or overnight in cold acid.
9. Stir, centrifuge and decant (place caps on centrifuge tubes during centrifugation). Check that all sand has dissolved by stirring the solution. If not, allow an additional 30 minutes in the water bath.
10. Decant suspension into 10ml glass centrifuge tubes using 10% HCl. Place in boiling water bath for 20 minutes to remove colloidal silicates.
11. Centrifuge and decant.
12. Wash with distilled water, centrifuge and decant.
13. Add 7ml glacial acetic acid. Stir, centrifuge and decant.
14. Add acetolysis mixture to each and place in heated water bath for 3 minutes.
    Acetolysis mixture : Mix 9 parts (9ml) acetic anhydride and 1 part (1ml) concentrated sulphuric acid. Place in a dry measuring cylinder and stir with a dry rod.
15. Stir, centrifuge and decant.
16. Add glacial acetic acid, centrifuge and decant.
17. Add 9ml distilled water and 1ml NaOH to obtain neutral pH. Stir, centrifuge and decant.
18. Wash with distilled water three times.
19. For the last wash, add two drops aqueous safranine stain. Centrifuge and decant.
20. Add 7ml TBA. Stir, centrifuge and decant.
21. Transfer suspension into labelled vials using TBA. Centrifuge and decant.
22. Add silicone oil equal in amount to sediment in vial. Store uncapped for 24 hours to allow TBA to evaporate.

ABSOLUTE POLLEN FREQUENCIES.

Modified from Davis (1965,1966).
The preparation of the samples is the same as for relative pollen counts, until step 21.

21. Suspension is transferred using TBA to graduated centrifuge tubes and the volume of the suspension record.
22. The residue and suspended pollen, of known volume, is poured onto an Erlenmeyer flask.
23. The graduated tube is rinsed with TBA and added to the flask, making suspension up to 10ml.
24. A stirring bar is placed in the flask, which is then corked and placed on a magnetic stirrer for 10 minutes.
25. When the pollen is evenly suspended, 0.02ml of the pollen-TBA suspension is drawn up using a micropipette. (Stirring should continue while portions of the suspension are removed).
26. The outside of the pipette should be wiped clean.

MOUNTING.

27. A drop of silicone oil is placed on the microscope slide.
28. The pipette is emptied drop by drop onto the silicone oil on the slide, which is on a warming table ($\pm$ 50^{0}C).
29. The pollen-TBA suspension dissolves in the oil and the alcohol then evaporates leaving the pollen.
30. Fresh TBA is used to rinse the pipette and added to the silicone oil and pollen on the slide.
31. After evaporation, a coverslip is placed over the fluid and left on the warming table until the mixture spreads to edges.
32. Several replicate slides should be prepared.

COUNTING.

33. The entire area under the coverslip must be counted.
34. All the pollen is identified and recorded.

35. The total number of grains in the original suspension is extrapolated from the number of grains counted per slide viz. 0.02ml.

TO STORE

36. Centrifuge the remaining TBA-pollen suspension. Decant.
37. Add silicone oil in equal amount to the residue in the vial.
38. Stir and leave uncapped overnight to enable remaining TBA to evaporate.

APPENDIX E.

WALKLEY-BLACK TECHNIQUE : DETERMINATION OF ORGANIC MATTER.

Adapted from Smith and Atkinson (1975).

REAGENTS :

49.035g $K_2Cr_2O_7$ dissolved in 1 litre distilled water.

Ferrous solution: 0.5M Ferrous ammonium sulphate prepared by dissolving 196.1g $Fe(NH_4)_2.6H_2O$ with 20ml conc. H_2SO_4 and diluting to 1 litre.

Diphenylamine indicator: 0.5g diphenylamine dissolved in 20ml distilled water.

100ml concentrated sulphuric acid (H_2SO_4).

50ml 85% Orthophosphoric acid (H_3PO_4).

PROCEDURE.

1. The oven-dried soil is ground to pass a 150 micrometre British Standards (BS) test sieve.
2. 1g is transferred to a 500ml conical flask.
3. 10ml $K_2Cr_2O_7$ is added, followed by 20ml conc. H_2SO_4.
4. Swirl flask gently for about 1 minute, ensuring no soil escapes contact with the reagent.
5. Allow flask and contents to cool for 20 minutes.
6. Dilute solution with 200ml distilled water and 10ml

85% orthophosphoric acid.

7. To this mixture, add 0.2g solid NaF and 1ml diphenylamine indicator.
8. This is titrated against the standard ferrous solution.
9. Initially, a dull green chromous colour is observed which turns blue, while the end-point is bluish-green.
10. A blank titration is run using the same procedure, but without adding soil.
11. This standardises the ferrous solution against chromic acid.

CALCULATIONS.

$$1 \text{ ml } K_2Cr_2O_7 = \frac{12}{4\,000} \times \frac{100}{77} \quad \text{or 0.0039 g carbon.}$$

$$\% \text{ organic carbon} = \frac{\text{ml } K_2Cr_2O_7 \text{ reduced} \times N \times 0.0039 \times 100}{\text{weight of soil}}$$

$$= \frac{(B - S) \times 0.5 \times 0.0039 \times 100}{\text{weight}}$$

where : B = Blank titration (ml)
S = Sample titration (ml)
N = Normality of Fe^{2+}

% organic matter = % carbon X 1.724

APPENDIX F.

SLIDE AND PHOTOGRAPH REFERENCE COLLECTION FOR THE CEDERBERG, WINTERBERG, NUWEVELDBERG, SNEEUBERG AND SWARTBERG RANGES (1989).

KEY :

@ : REPRESENTS SPECIES AVAILABLE IN THE PHOTOGRAPH COLLECTION

* : COLLECTED FROM ALBANY HERBARIUM (1985).
** : COLLECTED FROM ALBANY HERBARIUM (1986).
JS : COLLECTED IN FIELD BY JEAN SUGDEN.
FH : COLLECTED AT FORT HARE HERBARIUM (1986).
: COLLECTED AT BOLUS HERBARIUM (1987).
KI : COLLECTED AT KIRSTENBOSCH HERBARIUM (1987).
DU : EXCHANGED WITH DR D. LIVINGSTONE, DUKE UNIVERSITY, U.S.A.(1987 & 1988).
TH : EXCHANGED WITH TREVOR HILL, RHODES UNIVERSITY (1988).

ALL TAXA CATEGORISED ACCORDING TO GIBBS RUSSELL SPECIES NUMBERS.

@	#	0000020 00100	LYCOPODIUM CAROLINIANUM VAR CAROLIANUM	LYCOPODIACEAE
@	#*	0000020 00300	LYCOPODIUM CERNUUM L.	LYCOPODIACEAE
	DU	0000020 00400	LYCOPODIUM CLAVATUM	LYCOPODIACEAE
@	#*	0000030 00200	SELAGINELLA DREGEI (PRESL.) HIERON	SELAGINACEAE
	DU	0000030 00250	SELAGINELLA GRISEA ALSTON	SELAGINACEAE
@	#*	0000030 00400	SELAGINELLA KRAUSIANA (KUNZE.) A.BRAUN.	SELAGINACEAE
	DU	0000030 00550	SELAGINELLA PURPUSILA BAK	SELAGINACEAE
	DU	0000080 00100	OSMUNDA REGALIS L.	OSMUNDIACEAE
@	#	0000090 00100	TODEA BARBARA (L.)T.MOORE	OSMUNDIACEAE
@	#*	0000120 00100	MOHRIA CAFFRORUM (L.) DESV.	SCHIZACEAE
@	TH	0000150 00200	GLEICHENIA UMBRACULIFERA	GLEICHENIACEAE
	DU	0000160 00200	HYMENOPHYLLUM CAPILLARE DESV.	HYMENOPHYLLACEAE
	DU	0000160 00250	HYMENOPHYLLUM KUHNII CHR.	HYMENOPHYLLACEAE
@	#	0000160 00600	HYMENOPHYLLUM TUNBRIDGENSE (L.)J.E.SM.	HYMENOPHYLLACEAE
	DU	0000220 00000	DENNSTAEDTIA PUNCTYLOBULA (MX) MOORE	DENNSTAEDTIACEAE
	DU	0000240 00100	HYPOLEPSIS SPARSISARA SCHRED.	DENNSTAEDTIACEAE
@	DU	0000260 00100	PTERIDIUM AQUILINUM L.	DENNSTAEDTIACEAE
	#	0000260 00100	PTERIDIUM AQUILINUM(L.)KUHN	DENNSTAEDTIACEAE
@	TH	0000300 00400	ADIANTUM POIRETTI	ADIANTACEAE
@		0000300 00100	ADIANTUM CAPILLUS	ADIANTACEAE
@	*	0000340 00100	CHEILIANTHUS BERGIANA SCHLECHTER EX.KUNZE	ADIANTACEAE
@	*	0000340 00200	CHEILANTHES CAPENSIS (THUNB.) SWARTZ	ADIANTACEAE
@	#	0000340 00300	CHEILANTHES CONTRACTA (KUNZE)METT.EX KUHN.	ADIANTACEAE
@	TH	0000340 00600	CHEILANTHUS ECKLONII	ADIANTACEAE
@	*	0000340 00800	CHEILANTHES HIRTA SWARTZ.	ADIANTACEAE
@		0000340 01000	CHEILANTHES INAEQUIDENS	ADIANTACEAE
@	#	0000340 01100	CHEILANTHES INDUTA KUNZE	ADIANTACEAE
@	#	0000340 01300	CHEILANTHES MULTIFIDA (SWARTZ)SWARTZ SUBSP. MULTIFIDA	ADIANTACEAE
@	*	0000340 01480	CHEILANTHES QUADRIPINNATA (FORSSK.)KUHN.	ADIANTACEAE
@	*	0000340 01900	CHEILANTHES VIRIDIS	ADIANTACEAE
@	JS	0000360 00150	PELLAEA CALOMELANS L.	ADIANTACEAE
	JS	0000360 01400	PELLAEA QUADRIPINNATA	ADIANTACEAE
	JS	0000360 02000	PELLAEA VIRIDIS VAR. MICROPHYLLA	ADIANTACEAE
	JS	0000360 02500	PELLAEA VIRIDUS VAR. VIRIDUS	ADIANTACEAE
@		0000380 00300	PTERIS CRETIC	ADIANTACEAE
	DU	0000410 00000	CRYPTOGRAMMA STELLERI (GMEL) PRANTL	POLYPODIACEAE
@		0000450 00200	PLEOPELTIS MACROCARPA	POLYPODIACEAE

@		0000450	00400	PLEOPELTIS SCHRADEI	POLYPODIACEAE
@		0000460	00100	POLYPODIUM POLYPODIOIDES	POLYPODIACEAE
@	*	0000460	00200	POLYPODIUM VULGARE L.	POLYPODIACEAE
	DU	0000460	99999	POLYPODIUM SP.	POLYPODIACEAE
	DU	0000490	00100	DAVALLIA DENTICULATA	DAVALLIACEAE
@		0000520	00300	ASPLENIUM AETHIOPICUM	ASPLENIACEAE
@		0000520	00400	ASPLENIUM ANISOPHYLLUM	ASPLENIACEAE
@		0000520	00900	ASPLENIUM ERECTUM	ASPLENIACEAE
@		0000520	01900	ASPLENIUM MONANTHES	ASPLENIACEAE
@		0000520	03000	ASPLENIUM STOLONIFERUM	ASPLENIACEAE
@		0000520	03100	ASPLENIUM THECIFERUM	ASPLENIACEAE
@		0000520	03400	ASPLENIUM VARIANS	ASPLENIACEAE
@		0000520	03400	ASPLENIUM VARIANS VAR. FIMBRIATUM	ASPLENIACEAE
@		0000530	00100	CETERACH CORDATUM	ASPLENIACEAE
@		0000533	00100	CHRISTELLA QUEINZIANA	THELYPTERIDACEAE
@		0000540	00200	ATHRIUM SCHIMPERI	ATHYRIACEAE
@		0000580	00100	ELAPHOGLOSSUM ACROSTICHOIDES	LOMARIOPDSIDACEAE
@		0000630	00300	DRYUPTERUS INAEQUIDENS	ASPIDACEAE
@		0000630	00200	POLYSTICHIUM LUCTUOSUM	ASPIDACEAE
@		0000650	00650	POLYSTICHIUM SETIFERUM	ASPIDACEAE
@		0000660	00100	RUMCHRA ADIANTIFORMIS	ASPIDACEAE
@		0000680	00100	WOODSIA MONTEVIDENSIS	ASPIDACEAE
@	#	0000690	00200	BLECHNUM AUSTRALE L.	BLECHNACEAE
@	#	0000690	00350	BLECHNUM GIGANTEUM SCHLECHTD.	BLECHNACEAE
@	#	0000690	00400	BLECHNUM INFLEXUM (KUNZE) KUHN.	BLECHNACEAE
@	#	0000690	00500	BLECHNUM PUNCTULATUM SWARTZ VAR. PUNCTULATUM	BLECHNACEAE
@		0000700	00100	ALSOPHILLA DREGEI	CYANTHACEAE
	#	0001056	00200	RICCARDIA COMPACTA (STEPH.)S.ARNELL	ANEURACEAE
	#	0001172	00100	JUNGERMANNIA AUSTROAFRICANA S.ARNELL	JUNGERMANNIACEAE
	DU	0001216	99999	ANTHOCEROS SP.	ANTHOCEROTEAE
	DU	0001218	00000	DICRANOWEISIA CRISPULA	ANTHOCEROTEAE
	#	0001301	00500	SPHAGNUM TRUNCATUM HORNSCH.	SPHAGNACEAE
	#	0001306	00050	ANDREAEA BISTRATOSA MAGILL.	ANDREAECEAE
	#	0001306	00100	ANDREAEA NITIDA HOOK.F.& WILLIS	ANDREAECEAE
	DU	0001306	00200	ANDREAEA RUPESTRIS	ANDREAECEAE
@	#	0001316	04100	FISSIDENS RUBESCENS HOPNSCH.	FISSIDENTACEAE
@	#	0001333	00300	DITRICHUM DIFFICILE (DUB.)FLEISCH.	DITRACHNACEAE
@	#	0001359	00100	CAMPYLOPUS ATROLUTEUS (C.MUELL.) PAR.	DICRANIACEAE
	#	0001359	01200	CAMPYLOPUS INTROFLEXUS (HEDW.)BRID.	DICRANIACEAE
@	#	0001359	09000	CAMPYLOPUS CHLOROTRICHUS FALCATUM MAGILL	DICRANIACEAE
@	#	0001370	00100	CHORISDONTUM FALCATUM MAGILL.	DICRANIACEAE
@	#	0001368	00400	TREMATODON INTERMEDIUS WELW.& DUBY	DICRANIACEAE
@	#	0001387	00100	HYPODONTIUM DREGEI (HORNSCH.)C.MUELL	CALYMPERACEAE
@	#	0001404	00250	BARBULA CRINITA SCHULTZ	POTTIACEAE
@	#	0001407	99999	DIDYMODON SP.	POTTIACEAE
@	#	0001423	00100	TETRAPTERUM TETRAGONUM (HOOK.)ANDREWS	POTTIACEAE
@	#	0001427	00100	TRIQUETRELLA TRISTICHA (C.MUELL.)C.MUELL.	POTTIACEAE
@	#	0001446	00100	CHAMAEBRYUM POTTIOIDES THER.& DIX.	GIGASPERMACEAE
@	#	0001466	99999	ENTOSTHODON SP.	GIGASPERMACEAE
@	#	0001508	01300	BRYUM MUNDII	BRYACEAE
@	KI	0001512	00100	MIELICHHOFERIA REHMANNII	BRYACEAE
@	#	0001591	00050	BARTRAMIA ARISTARIA C.MUELL	BARTRAMIACEAE
@	#	0001591	00300	BARTRAMIA HAMPEANA C.MUELL.	BARTRAMIACEAE
@	#	0001583	00650	BREUTELIA SUBSTRICTA (C.MUELL.)MAGILL	BARTRAMIACEAE
@	#	0001583	99999	BREUTELIA SP.	BARTRAMIACEAE
@	#	0001612	00200	PTYCHOMITRIUM CRISPATUM (HEDW.)JAEG.	PHYTOCHOMITRIACEAE
@	#	0001923	00100	POLYTRICHUM COMMUNE HEDW.	POLYTRICHIACEAE

@	#	0013000 00100	PODOCARPUS LONGIFOLIUS (AIT.) L'HERIT. EX. PERS	PODOCARPACEAE
	DU	0022000 00000	JUNIPERUS COMMUNIS L.	PINACEAE
	DU	0022000 00000	JUNIPERUS SILICOLA (SMALL.) BAILEY	PINACEAE
	DU	0022000 00000	JUNIPERUS VIRGINIANA L.	PINACEAE
@	DU	0022000 00000	PINUS BANKSIANA LAMB	PINACEAE
	DU	0022000 00000	PINUS ELLIOTTII ELGELM	PINACEAE
	DU	0022000 00000	PINUS PATULA SCHLECHT. & CHAM.	PINACEAE
	DU	0022000 00000	PINUS RIGIDA MILL.	PINACEAE
	DU	0022000 00000	THUJA OCCIDENTALIS L.	PINACEAE
	DU	0022000 00000	TAXODIUM DISTICHUM (L.) RICH	PINACEAE
@	#	0038000 00100	WIDDRINGTONIA CEDARBERGENSIS MARSH.	CUPRESSACEAE
@	#	0065000 00300	APONOGETON DISTACHYOS L.F.	APONOGETONACEAE
@	#	0456000 00100	CARPHA BRACTEOSA C.B.CL.	CYPERACEAE
@	#	0456000 00300	CARPHA GLOMERATA (THUNB.)NEES.	CYPERACEAE
	TH	0459000 00850	CYPERUS COMPACTUS	CYPERACEAE
@	#	0459000 01900	CYPERUS ESCULENTUS L.	CYPERACEAE
@	#	0456900 02000	CYPERUS FASTIGATUS ROTTB.	CYPERACEAE
@	#	0459000 03500	CYPERUS LONGUS L.VAR.LONGUS.	CYPERACEAE
	DU	0459000 05000	CYPERUS PAPYRUS	CYPERACEAE
@	#	0459000 06400	CYPERUS RUPESTRIS KUNTH.	CYPERACEAE
@	#	0459000 07000	CYPERUS SPHAEROSPERMUS SCHRAD.	CYPERACEAE
@	#	0459000 07700	CYPERUS TENUIFLORUS L.F.	CYPERACEAE
@	#	0459010 01900	PYCREUS POLYSTACHYOS (ROTTB.) BEAUV. VAR. POLYSTACHYOS	CYPERACEAE
@	#	0459010 99999	PYCREUS SP.	CYPERACEAE
@	**	0459020 00100	JUNCELLUS LAEVIGATUS L.	CYPERACEAE
@	#	0459030 00500	MARISCUS CONGESTUS (VAHL.) C.B.CL.	CYPERACEAE
	#	0459030 00400	MARISCUS THUNBERGII (VAHL) SCHRAD.	CYPERACEAE
@	#	0465000 00200	FICINIA ACUMINATA (STEUD.) NEES	CYPERACEAE
@	#	0465000 00400	FICINIA ANCEPS NEES.	CYPERACEAE
@	#	0465000 00600	FICINIA ARGYROLOPA NEES.	CYPERACEAE
@	#	0465000 00950	FICINIA BREVIFOLIA NEES EX. KUNTH.	CYPERACEAE
@	*	0465000 01000	FICINIA BULBOSA (L.) NEES.	CYPERACEAE
@	#	0465000 01400	FICINIA CAPITELLA (THUNB.) NEES.	CYPERACEAE
@	#	0465000 01500	FICINIA CINNAMOMEA C.B.CL.	CYPERACEAE
@	**	0465000 02400	FICINIA ELONGATA BOECK.	CYPERACEAE
@	#	0465000 02500	FICINIA FASCICULARIS NEES.	CYPERACEAE
@	#	0465000 02700	FICINIA FILIFORMIS (LAM.) SCHRAD.	CYPERACEAE
@	#**	0465000 02800	FICINIA GRACILIS (POIR.) SCHRAD.	CYPERACEAE
@	#	0465000 02860	FICINIA GYDOMONTANA ARNOLD.	CYPERACEAE
@	#	0465000 02900	FICINIA INDICA (LAM.)PFEIFFER VAR. INDICA.	CYPERACEAE
@	#	0465000 03100	FICINIA IXIOIDES NEES SUBSP. IXIOIDES.	CYPERACEAE
@	#	0465000 03900	FICINIA MICRANTHA C.B.CL.	CYPERACEAE
@	#	0465000 03950	FICINIA NIGRESCENS (SCHRAD.) J.RAYNAL.	CYPERACEAE
@	#	0465000 05200	FICINIA SECUNDA (VAHL.) KUNTH.	CYPERACEAE
@	*	0465000 05400	FICINIA STRIATA (THUNB.) KUNTH.	CYPERACEAE
@	#	0465000 99999	FICINIA SP.	CYPERACEAE
@	**	0467000 00300	FUIRENA COERULESCENS STEUD.	CYPERACEAE
@	#	0467000 00800	FUIRENA HIRSUTA (BERG.)P.L.FORBES.	CYPERACEAE
@	**	0468000 01100	SCIRPUS DIOECUS (KUNTH.) BOECK.	CYPERACEAE
	FH	0468000 02300	SCIRPUS INANIS (THUNB.) STEUD.	CYPERACEAE
@	KI*	0468000 04500	SCIRPUS NODOSUS ROTTB.	CYPERACEAE
@	#	0468020 00740	ISOLEPIS PROLIFER R.BR.	CYPERACEAE
@	#	0471010 00400	BULBOSTYLIS BURCHELLII (FICAL. & HIERN) C.B.CL.	CYPERACEAE
@	#	0477010 00100	EPISCHOENUS ADNATUS LEVYNS.	CYPERACEAE
@	KI	0494000 01100	TETRARIA COMPAR (L.) LESTIB.	CYPERACEAE
@	KI	0494000 01400	TETRARIA CRINIFOLIA (NEES) C.B.CL.	CYPERACEAE
@	KI	0494000 01600	TETRARIA CUSPIDATA (POTTB.)C.B.CL.	CYPERACEAE

@	KI	0494000 02000	TETRARIA FASCIATA (ROTTB.)C.B.CL.	CYPERACEAE
@	KI	0494000 02100	TETRARIA FERRUGINEA C.B.CL.	CYPERACEAE
@	**	0494000 02400	TETRARIA FOURCADEI TURRIL & SCHONL.	CYPERACEAE
@	#	0494000 02900	TETRARIA LIGULATA C.B.CL.	CYPERACEAE
@	KI	0494000 03200	TETRARIA MACULATA SCHONL.& TURRILL	CYPERACEAE
@	KI	0494000 03700	TETRARIA PICTA (BOECK.)C.B.CL.	CYPERACEAE
@	KI	0494000 03900	TETRARIA PLOESTICHA C.B.CL.	CYPERACEAE
@	KI	0494000 04000	TETRARIA PUBESCENS SCHONL.& TURRILL	CYPERACEAE
@	KI	0494000 05100	TETRARIA TRIANGULARIS (BOEK.) C.B.CL.	CYPERACEAE
@	KI	0494000 05200	TETRARIA USTULATA (L.)C.B.CL.	CYPERACEAE
@	KI	0494000 05300	TETRARIA VAGINATA SCHONL.& TURRILL.	CYPERACEAE
@	KI	0494000 99999	TETRARIA SP.	CYPERACEAE
@	KI	0494010 00200	MACROCHAETIUM ECKLONII (NEES) LEVYNS.	CYPERACEAE
@	KI	0500000 00100	CHRYSITHRIX CAPENSIS L.VAR.CAPENSIS	CYPERACEAE
@	KI	0500000 00300	CHRYSITHRIX DODII C.B.CL.	CYPERACEAE
@	KI	0500000 00500	CHRYSITHRIX JUNCIFORMIS NEES.	CYPERACEAE
	DU	0515000 00800	SCLERIA BULBIFERA HOCHST. EX A. RICH	CYPERACEAE
@	#	0515000 03800	SCLERIA WOODII KUNTH.	CYPERACEAE
@	JS	0525000 02300	CAREX ZULUENSIS	CYPERACEAE
	DU	0684000 99999	ANCHOMANES SP.	ARACEAE
	DU	0684000 00000	XANTHOSOMA SAGITTIFOLIUM	ARACEAE
@	*	0748000 00100	ZANTEDESCHIA AETHIOPICA (L.)SPRENG.	ARACEAE
@	#	0804000 00200	RESTIO ARCUATUS MAST.	RESTIONACEAE
@	#	0804000 00500	RESTIO BIFURCUS NEES EX MAST.	RESTIONACEAE
@	#	0804000 00800	RESTIO BRUNNEUS PILLANS.	RESTIONACEAE
@	#	0804000 01800	RESTIO CINCINNATUS MAST.	RESTIONACEAE
@	#	0804000 02300	RESTIO CURVIRAMIS KUNTH.	RESTIONACEAE
@	#	0804000 02400	RESTIO CUSPIDATUS THUNB.	RESTIONACEAE
@	KI	0804000 02500	RESTIO CYMOSUS (MAST.)PILLANS	RESTIONACEAE
@	#	0804000 03100	RESTIO FILIFORMIS POIR.	RESTIONACEAE
@	JS	0804000 03500	RESTIO FRUTICOSUS THUNB.	RESTIONACEAE
@	#	0804000 03400	RESTIO FRATERNUS KUNTH.	RESTIONACEAE
@	#	0804000 03600	RESTIO GAUDICHAUDIANUS KUNTH. VAR GAUDICHAUDIANUS	RESTIONACEAE
@	#	0804000 03900	RESTIO GOSSYPINUS MAST.	RESTIONACEAE
@	#	0804000 04400	RESTIO LANIGER KUNTH VAR.LANIGER.	RESTIONACEAE
@	#	0804000 04900	RESTIO MARLOTHII PILLANS VAR. MARLOTH.	RESTIONACEAE
@	#	0804000 05200	RESTIO MISER KUNTH.	RESTIONACEAE
@	#	0804000 05300	RESTIO MONANTHUS MAST.	RESTIONACEAE
@	#	0804000 05420	RESTIO NANUS ESTERHUYSEN.	RESTIONACEAE
@	#	0804000 05450	RESTIO NODOSUS PILLANS	RESTIONACEAE
@	#	0804000 05700	RESTIO OCCULTUS (MAST.) PILLANS	RESTIONACEAE
@	#	0804000 05800	RESTIO OCREATUS KUNTH.	RESTIONACEAE
@	#	0804000 06100	RESTIO PATENS MAST.	RESTIONACEAE
@	#	0804000 06300	RESTIO PERPLEXUS KUNTH.	RESTIONACEAE
@	#	0804000 06900	RESTIO RHODOCOMA MAST.	RESTIONACEAE
@	#	0804000 06950	RESTIO RIVULUS ESTERHUYSEN	RESTIONACEAE
@	#	0804000 07800	RESTIO SIEBERI KUNTH. VAR. SIEBERI	RESTIONACEAE
@	#	0804000 07900	RESTIO SIEBERI KUNTH. VAR. VENUSTULUS (KUNTH.)PILLANS	RESTIONACEAE
@	#	0804000 08500	RESTIO STROBILIFER KUNTH.	RESTIONACEAE
@	#	0804000 09100	RESTIO TRITICEUS ROTTB.	RESTIONACEAE
@	#	0804000 09200	RESTIO TUBERCULATUS PILLANS.	RESTIONACEAE
@	JS	0804000 09400	RESTIO VIRGEUS MAST.	RESTIONACEAE
@	#	0804000 09500	RESTIO WALLICHII MAST.	RESTIONACEAE
@	#	0804000 99999	RESTIO SP.	RESTIONACEAE
@	#	0805000 00150	CHONDROPETALUM ALBO-ARISTATUM PILLANS.	RESTIONACEAE
@	#	0805000 00300	CHONDROPETALUM CAPITATUM (STEUD.) PILLANS.	RESTIONACEAE
@	#	0805000 00700	CHONDROPETALUM HOOKERIANUM (MAST.)	RESTIONACEAE

@	#	0805000 00750	CHONDROPETALUM INSIGNE PILLANS.	RESTIONACEAE
@	#	0805000 00800	CHONDROPETALUM MACROCARPUM (KUNTH.) PILLANS	RESTIONACEAE
@	#	0805000 01200	CHONDROPETALUM NITIDUM (MAST.)	RESTIONACEAE
@	#	0807000 00270	ELEGIA CAPENSIS (BURM.F.) SCHELPE	RESTIONACEAE
@	#	0807000 01500	ELEGIA NEESII (MAST.) MAST.	RESTIONACEAE
@	#	0807000 01600	ELEGIA PARVIFLORA KUNTH. VAR. FILACEA (MAST.) PILLANS.	RESTIONACEAE
@	#	0807000 01700	ELEGIA PARVIFLORA KUNTH VAR. PARVIFLORA	RESTIONACEAE
@	#	0808000 00400	LEPTOCARPUS DISTICHUS (ROTTB.)PILLANS	RESTIONACEAE
@	#	0808000 01000	LEPTOCARPUS MARLOTHII PILLANS	RESTIONACEAE
@	#	0808000 01300	LEPTOCARPUS PANICULATUS (ROTTB.)PILLANS	RESTIONACEAE
@	#	0808000 01500	LEPTOCARPUS RIGORATUS MAST VAR.RIGORATUS.	RESTIONACEAE
@	#	0808000 01800	LEPTOCARPUS VIMINEUS (ROTTB.) MAST.	RESTIONACEAE
@	#	0808000 99999	LEPTOCARPUS SP.	RESTIONACEAE
@	#	0813000 00050	THAMNOCHORTUS ACUMINATUS PILLANS	RESTIONACEAE
@	#	0813000 00200	THAMNOCHORTUS BACHMANNII MAST.	RESTIONACEAE
@	KI	0813000 00700	THAMNOCHORTUS ERECTUS (THUNB.) MAST.	RESTIONACEAE
@	KI	0813000 00900	THAMNOCHORTUS FRUTICOSUS BERG.	RESTIONACEAE
@	KI	0813000 02200	THAMNOCHORTUS SCHLECHTERI PILLANS	RESTIONACEAE
@	#	0814000 00100	STABEROMA AEMULA (KUNTH.) PILLANS.	RESTIONACEAE
@	#	0814000 00400	STABEROMA ORNATA ESTERHUYSEN.	RESTIONACEAE
@	KI	0814000 00500	STABEROMA VAGINATA (THUNB.)PILLANS.	RESTIONACEAE
@	#	0816000 00300	HYPODISCUS ARISTATUS (THUNB.)NEES VAR. ARISTATUS.	RESTIONACEAE
@	#	0816000 00600	HYPODISCUS BINATUS (STEUD.) MAST.	RESTIONACEAE
@	#	0816000 00700	HYPODISCUS NEESII MAST.	RESTIONACEAE
@	#	0816000 00790	HYPODISCUS SQUAMOSUS ESTERHUYSEN	RESTIONACEAE
@	#	0816000 00800	HYPODISCUS STRIATUS (KUNTH.) MAST.	RESTIONACEAE
@	KI	0817000 00100	CANNOMOIS PARVIFLORA (THUNB.)PILLANS	RESTIONACEAE
@	#	0817000 00300	CANNOMOIS DREGEI PILLANS	RESTIONACEAE
@	#	0817000 00300	CANNOMOIS DREGEI PILLANS 2	RESTIONACEAE
@	KI	0817000 00400	CANNOMOIS NITIDA (MAST.) PILLANS	RESTIONACEAE
@	KI	0817000 00500	CANNOMOIS PARVIFLORA (THUNB.) PILLANS	RESTIONACEAE
@	KI	0817000 00700	CANNOMOIS SCIRPOIDES MAST. VAR. PRIMOSII PILLANS	RESTIONACEAE
@	KI	0817000 00700	CANNOMOIS VIRGATA (ROTTB.) STEUD.	RESTIONACEAE
@	#	0817000 00250	CANNOMOIS CONGESTA	RESTIONACEAE
	KI	0817000 99999	CANNOMOIS SP.	RESTIONACEAE
	#	0818000 00100	WILLDENOWIA AFFINIS PILLANS	RESTIONACEAE
@	#	0818000 00200	WILLDENOWIA ARESCENS KUNTH.	RESTIONACEAE
@	#	0818000 00800	WILLDENOWIA LUCAEANA KUNTH.	RESTIONACEAE
@	#	0818000 00950	WILLDENOWIA STOKOEI PILLANS.	RESTIONACEAE
@	#	0818000 01000	WILLDENOWIA STRIATA THUNB.	RESTIONACEAE
@	#	0818000 01100	WILLDENOWIA SULCATA MAST.	RESTIONACEAE
	DU	0903000 00100	COLEOTRYPE NATALENSIS C.B.CLARK	COMMELINACEAE
	TH	0903000 00100	COMMELINA AFRICANA	COMMELINACEAE
	TH	0903000 01500	COMMELINA GERRARDI	COMMELINACEAE
	TH	0904000 00500	CYNOTIS SPECIOSA	COMMELINACEAE
@	JS	0936000 00200	JUNCUS ACUTUS L.	JUNCACEAE
@	#	0936000 00600	JUNCUS BUFONIS L.	JUNCACEAE
@	#	0936000 00700	JUNCUS CAPENSIS THUNB.	JUNCACEAE
@	**	0936000 01100	JUNCUS DREGEANUS KUNTH.	JUNCACEAE
@	**	0936000 01300	JUNCUS EXERTUS BUCHEN	JUNCACEAE
@	*	0936000 01850	JUNCUS LAEVIGATUS KUNTH.	JUNCACEAE
@	#	0936000 01900	JUNCUS LOMATOPHYLLUS SPRENG.	JUNCACEAE
@	#	0936000 02100	JUNCUS OBLIQUUS ADAMSON.	JUNCACEAE
@	JS	0936000 02900	JUNCUS RUPESTRIS KUNTH.	JUNCACEAE
	TH	0965000 00100	SANDERSONIA AURATIACA	LILIACEAE
@	KI	0969000 01800	ANDROCYMBIUM MELANTHIOIDES WILLD. VAR. MELANTHIOIDES	LILIACEAE
@	KI	0969000 02200	ANDROCYMBIUM SCABROMARGINATUM SCHLTR. & KRAUSE	LILIACEAE

	DU	0970000	00050	BAEMETRA COLUMEILARIS SALISB.	LILIACEAE
	DU	0970000	00100	BAEMETRA UNIFLORA LEWIS.	LILIACEAE
@	#	0971000	00100	ONIXOTIS PUNCTATA (L.) MABBERLEY	LILIACEAE
	DU	0972000	00155	WURMBEA CAPENSIS THUNB. VAR. LONGIFLORA.	LILIACEAE
@	#	0972000	00500	WURMBEA ELONGATA B.NORD	LILIACEAE
@	#	0972000	01450	WURMBEA SPICATA (BURM.F.)DUP.& SCHINZ	LILIACEAE
@	#	0972000	01460	WURMBEA SPICATA (BURM.F.)DUR.& SCHINZ VAR. USTULATA(B.NORD.) B.NORD.	LILIACEAE
@	#	0973000	00400	ORNITHOGLOSSUM PARVIFLORUM B. NORD. VAR. PARVIFLORUM.	LILIACEAE
@	#	0973000	00550	ORNITHOGLOSSUM VIRIDE (L.F.)AIT.	LILIACEAE
@	#	0984000	00350	BULBINELLA PUNCTULATA A.ZAHLBR.	LILIACEAE
@	#	0984000	00400	BULBINELLA TRIQUETRA (L.F.)KUNTH.	LILIACEAE
@	#	0985000	00200	BULBINE ALOOIDES (L.)WILLD.	LILIACEAE
@	JS	0985000	00205	BULBINE ALTISSIMA	LILIACEAE
@	#	0985000	02100	BULBINE MINIMA BAK.	LILIACEAE
@	*	0985000	02300	BULBINE NARASSIFOLIA SALM-DYK	LILIACEAE
@	#	0985000	03400	TRACHYANDRA JACQUINIANA (ROEM & SCHULT.)OBERM.	LILIACEAE
	TH	0989000	00500	ANTHERICUM COOPERI	LILIACEAE
@	#	0990000	01800	CHLOROPHYTUM UNDULATUM (JACQ.) OBERM.	LILIACEAE
@	#	1002000	00200	CAESIA CONTORTA (L.F.)DUR.& SCHINZ.	LILIACEAE
@	**	1012000	01500	ERIOSPERMUM CERNUUM BAK.	LILIACEAE
@	#	1012000	01900	ERIOSPERMUM CONFERTUM BAK.	LILIACEAE
@	#	1012000	04600	ERIOSPERMUM PARADOXUM (JACQ.)KER-GAWL.	LILIACEAE
@	**	1024000	02800	KNIPHOFIA NORTHIAE BAK.	LILIACEAE
@	**	1024000	04400	KNIPHOFIA TRIANGULARIS KUNTH.	LILIACEAE
@	*	1024000	04900	KNIPHOFIA UVARIA (L.)OKEN.	LILIACEAE
@	#	1026000	03300	ALOE CLAVIFLORA BURCH.	LILIACEAE
@	**	1026000	05400	ALOE FEROX MILL.	LILIACEAE
@	#	1026000	05900	ALOE GLAUCA MILL.VAR. GLAUCA.	LILIACEAE
	DU	1027000	03600	GASTERIA MACULATA	LILIACEAE
@	**	1027000	04200	GASTERIA OBTUSIFOLIA	LILIACEAE
@	**	1027000	05400	GASTERIA PULCHRA	LILIACEAE
@	**	1027000	99999	GASTERIA SP.	LILIACEAE
@	**	1029000	16700	HAWORTHIA TESSELATA	LILIACEAE
	TH	1046000	00300	AGAPANTHUS CAMPANULATUS	LILIACEAE
@	*	1046000	01900	AGAPANTHUS PRAECAX WILLD.	LILIACEAE
	DU	1047000	00200	TULBAGHIA ALLIACEAE L.F.	LILIACEAE
	DU	1047000	00300	TULBAGHIA CAMERONI BAK.	LILIACEAE
	TH	1047000	01400	TULBAGHIA LEUCANTHA	LILIACEAE
@	**	1079000	05500	ALBUCA SPIRALIS L.F.	LILIACEAE
@	#	1079000	99999	ALBUCA SP.	LILIACEAE
@	#	1080010	00200	TENICROA FILIFOLIA (JACQ.)OBERM.	LILIACEAE
	TH	1081000	00100	GALTONIA CANDICANS	LILIACEAE
@	#	1083000	00300	RHADAMANTHUS CONVALLARIOIDES (L.F.) BAK.	LILIACEAE
@	#	1083000	00500	RHADAMANTHUS MANTANUS B.NORD.	LILIACEAE
@	**	1084000	01300	DIPCADI VIRIDE (L.) MOENCH.	LILIACEAE
	DU	1084000	01150	DIPCADI SEROTINUM MEDIC.	LILIACEAE
	DU	1085000	00000	TULPIA FRAGRANS (MUNBY)	LILIACEAE
	TH	1086000	00300	SCILLA NERVOSA	LILIACEAE
@	**	1089000	01500	ORNITHOGALUM CONICUM JACQ.	LILIACEAE
@	#	1089000	02800	ORNITHOGALUM HISPIDUM HOPNEM. SUBSP. HISPIDUM.	LILIACEAE
	**	1089000	03200	ORNITHOGALUM JUNCEIFOLIUM JACQ.	LILIACEAE
@	#	1089000	03700	ORNITHOGALUM MACULATUM JACQ.	LILIACEAE
@	#	1089000	04200	ORNITHOGALUM NANODES LEIGHTON.	LILIACEAE
@	#	1089000	06800	ORNITHOGALUM SUAVEOLENS JACQ.	LILIACEAE
@	*	1089000	06940	ORNITHOGALUM TENUIFOLIUM DELORCHE	LILIACEAE
@	#	1089000	06970	ORNITHOGALUM THERMOPHILUM LEIGHTON.	LILIACEAE

@	#	1089000 07000	ORNITHOGALUM THYRSOIDES JACQ.	LILIACEAE
@	#	1098000 00400	LACHENALIA BACHMANNII BAK.	LILIACEAE
@	**	1098000 00550	LACHENALIA BOWKERI BAK.	LILIACEAE
@	#	1098000 01200	LACHENALIA CONTAMINATA AIT.	LILIACEAE
@	#	1098000 01610	LACHENALIA GLAUCINA (L.) AIT	LILIACEAE
@	#	1098000 02900	LACHENALIA MUTABILIS SWEET.	LILIACEAE
@	#	1098000 05200	LACHENALIA UNICOLOR JACQ.	LILIACEAE
@	KI	1099010 00300	NEOBAKERIA HETERANDRA LEIGHTON	LILIACEAE
@	#	1101000 00200	MASSONIA ECHINATA L.F.	LILIACEAE
@	#	1101000 00500	MASSONIA PUSTULATA JACQ.	LILIACEAE
@	*	1113000 00400	PROTASPARAGUS AFRICANUS LAM.	LILIACEAE
@	#	1113000 00500	PROTASPARAGUS ASPARAGOIDES (L.)WIGHT	LILIACEAE
@	*	1113000 00800	PROTASPARAGUS CAPENSIS L.	LILIACEAE
@	*	1113000 01400	PROTASPARAGUS DENUDATUS (KUNTH.)BAK.	LILIACEAE
@	#	1113000 01800	PROTASPARAGUS FASCICULATUS THUNB.	LILIACEAE
@	*	1113000 02100	PROTASPARAGUS KREBSIANUS (KUNTH.)JESSOP.	LILIACEAE
@	*	1113000 02200	PROTASPARAGUS LARICINUS BURCH.	LILIACEAE
@	**	1113000 02600	PROTASPARAGUS MUCRANATUS	LILIACEAE
@	*	1113000 03000	PROTASPARAGUS RACEMOSUS	LILIACEAE
@	*	1113000 03800	PROTASPARAGUS STRIATUS (L.F.)THUNB.	LILIACEAE
	*	1113000 03800	PROTASPARAGUS SUAVEOLENS BURCH.	LILIACEAE
@	#	1113000 04200	PROTASPARAGUS UNDULATUS (L.F.)THUNB.	LILIACEAE
@	#	1160000 00200	DILARIS IXIOIDES LAM.	HAEMODORACEAE
@	#	1162000 00300	WACHENDORFIA PANICULATA BURM.	HAEMODORACEAE
	DU	1162000 00300	WACHENDORFIA PANICULATA BURM.	HAEMODORACEAE
@	#	1162000 00500	WACHENDORFIA THYRSIFLORA L.	HAEMODORACEAE
@	#	1166000 01000	HESSEA STELLARIS (JACQ.) HERB.	AMARYLLIDACEAE
@	#	1166000 01300	HESSEA ZEYHERI BAK.	AMARYLLIDACEAE
@	#	1167000 01200	HAEMANTHUS COCCINEUS L.	AMARYLLIDACEAE
@	#	1167000 03400	HAEMANTHUS SANGUINEUS JACQ.	AMARYLLIDACEAE
	DU	1171000 00800	STRUMARIA TRUNCATA JACQ.	AMARYLLIDACEAE
@	*	1175000 00400	NERINE FILIFOLIA BAK.	AMARYLLIDACEAE
@	#	1175000 00950	NERINE HUMILIS (JACQ.) HERB.	AMARYLLIDACEAE
	DU	1175000 01250	NERINE LUCIDA DUR.& SCHINZ	AMARYLLIDACEAE
	**	1175000 99999	NERINE SP.	AMARYLLIDACEAE
	DU	1177000 00350	BRUNSVIGIA COOPERI BAK.	AMARYLLIDACEAE
@	*	1177000 00400	BRUNSVIGIA GRANDIFLORA UNDL.	AMARYLLIDACEAE
@	*	1177000 00500	BRUNSVIGIA GREGARIA R.A.DYER	AMARYLLIDACEAE
@	#	1177000 00900	BRUNSVIGIA MARGINATA (JACQ.) GARSIDE.	AMARYLLIDACEAE
	DU	1186000 00300	GETHYLLIS BRITTENAINA BAK.	AMARYLLIDACEAE
@	KI	1186000 01600	GETHYLLIS SPIRALIS (THUNB.)THUNB.	AMARYLLIDACEAE
@	KI	1186000 00000	GETHYLLIS VILLOSA BOL.	AMARYLLIDACEAE
	TH	1191000 01000	CYRTANTHUS CONTRACTUS	AMARYLLIDACEAE
	TH	1230000 02900	HYPOXIS MEMBRANACEAE	HYPOXIDACEAE
	TH	1230000 04100	HYPOXIS RIGIDULA	HYPOXIDACEAE
@	*	1230000 99999	HYPOXIS SP.	HYPOXIDACEAE
@	#	1230010 00600	SPILOXENE UMBRATICOLA (SCHLTR.)GARSIDE	HYPOXIDACEAE
	TH	1230020 00100	RHODOHYPOXIS BAURII	HYPOXIDACEAE
@	#	1233000 00100	CYANELLA ALBA L.F.	TECOPHILACEAE
@	KI	1233000 00300	CYANELLA HYACINTHOIDES L.	TECOPHILACEAE
@	#	1233000 00700	CYANELLA ORCHIDIFORMIS JACQ.	TECOPHILACEAE
@	#	1261000 00500	ROMULEA ATRANDRA G.J.LEWIS VAR.ESTERHUYSENIAE DE VOS	IRIDACEAE
@	#	1261000 01600	ROMULEA CRUCIATA (JACQ.) BAK. VAR. INTERMEDIA (BEG.)	IRIDACEAE
@	#	1261000 06600	ROMULEA ROSEA (L.) ECK. VAR. REFLEXA (ECKL.) BEG.	IRIDACEAE
@	#	1262000 00400	GALAXIA OVATA THUNB.	IRIDACEAE
@	#	1265000 00600	MORAEA ANOMALA G.J.LEWIS	IRIDACEAE
@	#	1265000 00950	MORAEA BARKERAE GOLDBL.	IRIDACEAE

@	#	1265000	01850	MORAEA CILIATA (L.F.)KER-GAWL.	IRIDACEAE
@	#	1265000	02020	MORAEA CRISPA THUNB.	IRIDACEAE
	DU	1265000	02250	MORAEA EDULIS KER-GAWL.	IRIDACEAE
@	#	1265000	03000	MORAEA FUGAX (DELAROCHE) JACQ.	IRIDACEAE
@	#	1265000	03650	MORAEA GRACILENTA GOLDBL.	IRIDACEAE
@	#	1265000	05900	MORAEA PAPILIONACEAE (L.F.)KER-GAWL.	IRIDACEAE
	DU	1265000	07000	MORAEA TEXTILIS BAKER	IRIDACEAE
@	*	1265000	07100	MORAEA SPATHULATA (L.F.)KLATT.	IRIDACEAE
@	FH	1265000	07250	MORAEA SPECIOSA (L.BOL.) GOLDBL.	IRIDACEAE
@	#	1265000	08000	MORAEA UNGILATA KER-GAWL.	IRIDACEAE
@	#	1265020	00500	GYNANDRIRIS SIMULANS (BAK.)R.C.FOST.	IRIDACEAE
@	#	1277000	00150	HOMERIA AUTUMNALIS GOLDBL.	IRIDACEAE
@	#	1277000	00450	HOMERIA CEDARMONTANA GOLDBL.	IRIDACEAE
@	#	1277000	00600	HOMERIA COOKII L.BOL.	IRIDACEAE
@	KI	1277000	00750	HOMERIA FENESTRATA GOLDBL.	IRIDACEAE
@	#	1277000	00800	HOMERIA FLACCIDA SWEET.	IRIDACEAE
@	#	1277000	00850	HOMERIA FLAVESCENS GOLDBL.	IRIDACEAE
@	#	1277000	02000	HOMERIA MINIATA (ANDR.)SWEET.	IRIDACEAE
@	#	1277000	02100	HOMERIA OCHROLEUCA SALISB.	IRIDACEAE
	DU	1277000	03000	HOMERIA SPECIOSA L.	IRIDACEAE
@	#	1277000	03250	HOMERIA TENUIS SCHLTR.	IRIDACEAE
@	KI	1277020	00100	RHOEME MAXIMILIANA (SCHLTR.)GOLDBL.	IRIDACEAE
@	#	1284000	00250	BOBARTIA FASCICULATA J.B.GILLETT EX STRID.	IRIDACEAE
@	#	1284000	01100	BOBARTIA MACROSPATHA BAK.SUBSP.ANCEPS (BAK.) STRID.	IRIDACEAE
@	#	1295000	00100	ARISTEA AFRICANA (L.)HOFFMG.	IRIDACEAE
@	*	1295000	00200	ARISTEA ANCEPS ECKL. EX.KLATT	IRIDACEAE
	DU	1295000	00850	ARISTEA CAPITATA KEW.	IRIDACEAE
@	#	1295000	01200	ARISTEA CUSPIDATA SCHINZ.	IRIDACEAE
@	#	1295000	01300	ARISTEA DICHOTOMA (THUNB.) KER-GAWL.	IRIDACEAE
@	#	1295000	02800	ARISTEA OLIGOCEPHALA BAK.	IRIDACEAE
	DU	1296000	00100	WITSENIA MAURA THUNB.	IRIDACEAE
@	#	1300000	00100	GEISSORHIZA ASPERA GOLDBL.	IRIDACEAE
@	#	1300000	00500	GEISSORHIZA BOLUSII BOLUSII BAK.	IRIDACEAE
@	#	1300000	00750	GEISSORHIZA CEDARMONTANA GOLDBL. MS.	IRIDACEAE
@	#	1300000	00790	GEISSORHIZA CONFUSA GOLDBL.	IRIDACEAE
@	#	1300000	02700	GEISSORHIZA JUNCEA (LINK.) A DIETR.	IRIDACEAE
@	#	1300000	03050	GEISSORHIZA LONGIFOLIA (G.J.LEWIS) GOLDBL.	IRIDACEAE
@	#	1300000	03200	GEISSORHIZA LOUISABOLUSAE R.C.FOST VAR. LOUSIBOLUSAE	IRIDACEAE
@	#	1300000	14600	GEISSORHIZA PARVA BAK.	IRIDACEAE
@	#	1300000	05520	GEISSORHIZA SCILLARIS A DIETR.	IRIDACEAE
@	#	1300000	06400	GEISSORHIZA UMBROSA G.J.LEWIS	IRIDACEAE
@	#	1300000	99999	GEISSORHIZA SP.	IRIDACEAE
@	#	1300010	00300	ENGYSIPHON LONGETUBUS G.J.LEWIS	IRIDACEAE
@	#	1301000	00250	HESPERANTHA BACHNANNII BAK.	IRIDACEAE
@	#	1301000	00800	HESPERANTHA FALCATA (L.F.)KER-GAWL.	IRIDACEAE
@	#	1301000	00850	HESPERANTHA ELSIAE GOLDBL.	IRIDACEAE
	**	1301000	02800	HESPERANTHA RADIATA	IRIDACEAE
@	#	1302000	00500	IXIA CAPILLARIS L.F.	IRIDACEAE
@	#	1302000	02700	IXIA MACULATA L.VAR.MACULATA.	IRIDACEAE
@	#	1302000	04100	IXIA PAUCIFOLIA G.J.LEWIS	IRIDACEAE
@	#	1302000	04700	IXIA RAPUNCULOIDES DEL. VAR. NAMAQUANA (L. BOL.) G.J.LEWIS	IRIDACEAE
@	#	1302000	05300	IXIA SCILLARIS L.VAR. SCILLARIS	IRIDACEAE
@	*	1303000	01700	DIERAMA PANSUM N.E.BR.	IRIDACEAE
@	*	1303000	01900	DIERAMA PENDULUM BAK.	IRIDACEAE
	TH	1303000	02400	DIERAMA ROBUSTA	IRIDACEAE
@	#	1306000	00550	TRITONIA CRISPA (L.F.)KER-GAWL.VAR.CRISPA.	IRIDACEAE
@	*	1306000	02000	TRITONIA LINEATA	IRIDACEAE

@	*	1306000	02500	TRITONIA SECUGERE (AIT.) KER-GAWL.	IRIDACEAE
@	#	1307000	00200	SPARAXIS ELEGANS (SWEET) GOLDBL.	IRIDACEAE
@	#	1309000	00400	SYNNOTIA VARIEGATA SWEET (L.BOL.)G.J.LEWIS	IRIDACEAE
@	#	1310000	00950	BABIANA DISTICHA KER-GAWL.	IRIDACEAE
@	#	1310000	01100	BABIANA ECKLONII KLATT VAR.ECKLONII.	IRIDACEAE
@	#	1310000	03600	BABIANA MUCRONATA (JACQ.)KER-GAWL. VAR. MUCRONATA	IRIDACEAE
@	KI	1310000	04600	BABIANA PILLOSA G.J.LEWIS	IRIDACEAE
	DU	1310000	04700	BABIANA PLICATA KER-GAWL.	IRIDACEAE
@	#	1310000	05400	BABIANA SAMBUCINA (JACQ.)KER-GAWL. VAR. SAMBUCINA.	IRIDACEAE
@	#	1310000	05900	BABIANA SCABRIFOLIA (BREHM.) EX. KLATT. VAR. SCABRIFOLIA.	IRIDACEAE
@	#	1311000	00200	GLADIOLUS ALATUS L.VAR.ALATUS.	IRIDACEAE
@	#	1311000	00700	GLADIOLUS ANGUSTUS L.	IRIDACEAE
@	#	1311000	02500	GLADIOLUS CARINATUS AIT.SUBSP.CARINATUS.	IRIDACEAE
	TH	1311000	04000	GLADIOLUS ECKLONII	IRIDACEAE
@	#	1311000	05900	GLADIOLUS HYALINUS JACQ.	IRIDACEAE
@	#	1311000	06050	GLADIOLUS INFLATUS THUNB.SUBSP.INFLATUS VAR. LOUISEAE (L.BOL.)OBERM.	IRIDACEAE
@	#	1311000	07000	GLADIOLUS LILIACEUS HOUTT.	IRIDACEAE
@	#	1311000	08800	GLADIOLUS ODORATUS L.BOL.	IRIDACEAE
@	#	1311000	10300	GLADIOLUS PRITZELII DIELS VAR.PRITZELII.	IRIDACEAE
@	#	1311000	11500	GLADIOLUS SCULLYI BAK.	IRIDACEAE
@	#	1311000	12700	GLADIOLUS TRISTIS L.VAR.TRISTIS.	IRIDACEAE
@	#	1311000	12900	GLADIOLUS UYSIAE L.BOL.EX G.J.LEWIS.	IRIDACEAE
@	#	1312010	01100	TRITONIOPSIS NEMOROSA (E.MEY.EX KLATT) G.J. LEWIS.	IRIDACEAE
@	#	1312010	01200	TRITONIOPSIS NERVOSA (BAK.)G.J.LEWIS	IRIDACEAE
@	#	1312010	01400	TRITONIOPSIS PARVIFLORA (JACQ.)G.J.LEWIS.	IRIDACEAE
@	#	1312010	01700	TRITONIOPSIS RAMOSA (ECKL.EX KLATT)G.J.LEWIS VAR.RAMOSA.	IRIDACEAE
@	#	1312020	00500	ANAPALINA NERVOSA (THUNB.)G.J.LEWIS.	IRIDACEAE
@	#	1313000	00100	MICRANTHUS ALOPECUROIDES (L.)ROTHM.	IRIDACEAE
@	#	1313030	00100	THEREIANTHUS BRACTEOLATUS (LAM.)G.J.LEWIS.	IRIDACEAE
@	#	1311400	00100	LAPEIROUSIA ANCEPS (L.F.)KER-GAWL.	IRIDACEAE
@	#	1314000	00900	LAPEIROUSIA DIVARICATA BAK.VAR.DIVARICATA	IRIDACEAE
@	#	1314000	01800	LAPEIROUSIA FABRICII (DELAROCHE)KER-GAWL.	IRIDACEAE
@	#	1314000	01900	LAPEIROUSIA FALCATA (L.F.)KER-GAWL.	IRIDACEAE
@	#	1314000	02000	LAPEIROUSIA JACQUINII N.E.BR.	IRIDACEAE
@	#	1314000	02100	LAPEIROUSIA MICRANTHA (E.MEY.EX KLATT.)BAK.	IRIDACEAE
	**	1314000	02500	LAPEIROUSIA PLICATA (JACQ.) DIELS.	IRIDACEAE
@	**	1314000	03150	LAPEIROUSIA TESSELATA GOLDBL.	IRIDACEAE
	DU	1315000	01400	WATSONIA FLAVIDA BOLUS	IRIDACEAE
@	#	1315000	02400	WATSONIA MARGINATA (L.F.)KER-GAWL.	IRIDACEAE
@	**	1315000	02500	WATSONIA MERIANA (L.)MILL.	IRIDACEAE
	DU	1315000	02500	WATSONIA MERIANA (L.)MILL.	IRIDACEAE
	TH	1315000	02500	WATSONIA MERIANA (L.)MILL.	IRIDACEAE
@	#	1315000	03500	WATSONIA STOKOEI L.BOL.	IRIDACEAE
@	#	1315000	99999	WATSONIA SP.	IRIDACEAE
	DU	1407000	00100	STENOGLOTTIS FIMBRIATA LINDL.	ORCHIDACEAE
	DU	1408000	00000	HOLOTHRIX HARVEIANA LINDL.	ORCHIDACEAE
@	**	1408000	02600	HOLOTHRIX VILLOSA LINDL.	ORCHIDACEAE
@	#	1430000	00300	SCHIZODIUM FLEXUOSUM (L.) LINDL.	ORCHIDACEAE
@	**	1430000	02650	SATYRIUM LONGICOLLA LINDL.	ORCHIDACEAE
@	#	1430000	04850	SATYRIUM STENOPETALUM LINDL. SUBSP. BREVICALCARTUM (H.BOL.) A.V.HALL	ORCHIDACEAE
@	#	1432000	00050	SCHIZODIUM BIFIDUM (THUNB.)REICHB.F.	ORCHIDACEAE
@	#	1432000	00400	SCHIZODIUM INFLEXUM LINDL.	ORCHIDACEAE
@	#	1434000	00600	DISA CAULESCENS LINDL.	ORCHIDACEAE
@	#	1434000	07100	DISA VENOSA SWART.	ORCHIDACEAE
	DU	1435000	00350	HERSCHELIA BAWIN	ORCHIDACEAE

@	#	1436000	00400	MONADENIA BRACTEATA (SWARTZ)DUR &SCHINZ.	ORCHIDACEAE
@	#	1436000	00600	MONADENIA COMOSA REICHB.F.	ORCHIDACEAE
@	#	1438000	00400	PTERYGODIUM CATHOLICUM (L.) SWARTZ	ORCHIDACEAE
	DU	1516000	00100	PLATYLEPIS GLANDULOSA	ORCHIDACEAE
	DU	1648000	00350	EULOPHIA BUCHANANI BOLUS	ORCHIDACEAE
	DU	1838000	00000	PLATANTHERA ZEYHERI (SOND.)	ORCHIDACEAE
@	JS	1872000	00100	POPULUS ALBA L.	SALICACEAE
	DU	1872000	00000	POPULUS BALSAMIFERA MILL.	SALICACEAE
	DU	1872000	00150	POPULUS DELTOIDES SARGENT	SALICACEAE
	DU	1872000	00000	POPULUS ILICIFOLIA (ENGL.) ROULEAU.	SALICACEAE
@	FH	1872000	00200	POPULUS NIGRA L.	SALICACEAE
	DU	1872000	00000	POPULUS TREMULOIDES MICHX.	SALICACEAE
@	#	1873000	00200	SALIX CAPREA	SALICACEAE
	DU	1873000	00000	SALIX DISCOLOR MUHL.	SALICACEAE
@	#	1873000	00500	SALIX HIRSUTA THUNB.	SALICACEAE
	DU	1873000	00550	SALIX HUMILIS MARSH	SALICACEAE
	DU	1873000	00560	SALIX HUTCHINSII SKAN.	SALICACEAE
@	*	1874000	00100	MYRICA BREVIFOLIA E.MEY.EX DC.	MYRICACEAE
	DU	1874000	00000	MYRICA CALIFORNICA CHAM.	MYRICACEAE
	DU	1874000	00000	MYRICA INODORA BARTE.	MYRICACEAE
@	#	1874000	00500	MYRICA INTEGRA	MYRICACEAE
	DU	1894000	00000	ULMUS ALATA	ULMACEAE
	DU	1898000	00000	CELTIS ZENKERI ENGL.	ULMACEAE
	DU	0000000	00000	FAGUS GRANDIFOLIA EHRH.	FAGACEAE
	DU	0000000	00000	QUERCUS COCCINEA L.	FAGACEAE
	DU	0000000	00000	QUERCUS FALCATA L.	FAGACEAE
	DU	0000000	00000	QUERCUS NIGRA L.	FAGACEAE
	DU	0000000	00000	ALNUS CRISPA (AIT.) PURSH.	BETULACEAE
	DU	0000000	00000	ALNUS INCANA (L.) MOENCH.	BETULACEAE
	DU	0000000	00000	ALNUS RUGOSA (D.A. ROI.) SPRENG.	BETULACEAE
	DU	0000000	00000	ALNUS SERRULATA (AIT.) WILLD	BETULACEAE
	DU	0000000	00000	BETULA ALBA	BETULACEAE
	DU	0000000	00000	BETULA LENTA	BETULACEAE
	DU	0000000	00000	BETULA NIGRA L.	BETULACEAE
	DU	0000000	00000	BETULA PAPYRIFERA MARSH.	BETULACEAE
	DU	0000000	00000	BETULA POPULIFOLIA MARSH.	BETULACEAE
	DU	0000000	00000	CORYLUS AMERICANA WALT.	BETULACEAE
	DU	0000000	00000	ACER OBLONGUM WELL.	ACERACEAE
	DU	0000000	00000	ACER RUBRUM	ACERACEAE
	DU	0000000	00000	ACER SACCHARUM MARSH.	ACERACEAE
	DU	0000000	00000	HYDRANGEA ARBORESCENS L.	HYDRANGEACEAE
	DU	0000000	00000	LEPTOLAENA BOJERIANA (H.BR) CAVACO	SARCOLAENACEAE
	DU	0000000	00000	HEUCHERA PUBESCENS PURSH.	SAXIFRAGACEAE
	DU	0000000	00000	SAXIFRAGA VIRGINIENSIS	SAXIFRAGACEAE
@	#	1961000	00700	FICUS CORDATA THUNB.	MORACEAE
	**	2012000	00100	FORSSKAOLEA CANDIDA L.F.	URTICACEAE
@	#	2024000	00100	BRABEIUM STELLATIFOLIUM L.	PROTEACEAE
@	#	2028000	00700	SOROCEPHALUS LANATUS (THUNB.)R.BR.	PROTEACEAE
@	#	2029000	00300	PARANOMUS BOLUSII	PROTEACEAE
@	#	2029000	00400	PARANOMUS BRACTEOLUARIS SALISB. EX KNIGHT.	PROTEACEAE
@	#	2029000	01600	PARANOMUS SPICATUS (BERG.)KUNTZE.	PROTEACEAE
@	#	2029000	01700	PARANOMUS TOMENTOSUS (PHILL.& HUTCH.) N.E.BR.	PROTEACEAE
@	#	2030000	00300	SERRURIA AEMULA R.BR.VAR.AEMULA.	PROTEACEAE
@	#	2030000	00500	SERRURIA AITHONII R.BR.	PROTEACEAE
@	#	2030000	02400	SERRURIA CYGNEA R.BR.	PROTEACEAE

@	#	2030000	03400	SERRURIA FLAVA E.MEY.	PROTEACEAE
@	#	2030000	03950	SERRURIA FURCELLATA R.BR.	PROTEACEAE
@	#	2030000	04900	SERRURIA LEIPOLDTII PHILL & HUTCH.	PROTEACEAE
@	#	2030000	05300	SERRURIA MILLEFOLIA KNIGHT.	PROTEACEAE
@	#	2030000	99999	SERRURIA SP.	PROTEACEAE
@	#	2032000	00300	SPATALLA CAUDATA (THUNB.)R.BR.	PROTEACEAE
@	#	2032000	00500	SPATALIA CONFUSA (PHILL.)ROURKE.	PROTEACEAE
@	#	2032000	00800	SPATALIA INCURVA (THUNB.)R.BR.	PROTEACEAE
@	#	2035000	00100	PROTEA ACAULOS (L.)REICHARD	PROTEACEAE
@	#	2035000	00300	PROTEA ACUMINATA SIMS.	PROTEACEAE
	DU	2035000	00000	PROTEA ANGOLENSIS WELW.	PROTEACEAE
@	#	2035000	00500	PROTEA ANGUSTATA R.BR.	PROTEACEAE
@	*	2035000	01200	PROTEA CAFFRA MEISN.	PROTEACEAE
@	#	2035000	02000	PROTEA CRYOPHILA H.BOL.	PROTEACEAE
@	*	2035000	02200	PROTEA CYNAROIDES L.	PROTEACEAE
	TH	2035000	02500	PROTEA DRACOMANTANA	PROTEACEAE
@	#	2035000	03100	PROTEA GLABRA THUNB.	PROTEACEAE
	DU	2035000	00000	PROTEA KILIMANDSCHARICA ENGL.	PROTEACEAE
@	*	2035000	03750	PROTEA LAETENS L.E.DAVIDSON	PROTEACEAE
@	#	2035000	03800	PROTEA LAEVIS R.BR.	PROTEACEAE
@	#	2035000	04100	PROTEA LAURIFOLIA THUNB.	PROTEACEAE
	DU	2035000	04650	PROTEA MADIENSIS OLIV.	PROTEACEAE
@	*	2035000	05400	PROTEA NANA.	PROTEACEAE
@	#	2035000	05550	PROTEA NITIDA MILL.	PROTEACEAE
@	#	2035000	06100	PROTEA PENDULA R.BR.	PROTEACEAE
@	*	2035000	06200	PROTEA PITYPHYLLA PHILL.	PROTEACEAE
@	#	2035000	06500	PROTEA PUNCTATA MEISN.	PROTEACEAE
@	#	2035000	06600	PROTEA RECONDITA BUEK. EX MEISN.	PROTEACEAE
@	#	2035000	06650	PROTEA REPENS (L.)L.	PROTEACEAE
	TH	2035000	08500	PROTEA SUBVESTITA	PROTEACEAE
@	#	2035000	09400	PROTEA WITZENBERGIANA PHILL.	PROTEACEAE
	*	2035000	99999	PROTEA SP.	PROTEACEAE
@	#	2036000	00500	LEUCOSPERMUM CALLIGERUM (SALISB.EX KNIGHT) ROURKE.	PROTEACEAE
	*	2036000	02100	LEUCOSPERMUM DAPHNOIDES (THUNB.) MEISN.	PROTEACEAE
@	#	2036000	03700	LEUCOSPERMUM REFLEXUM BUEK. EX MEISN. VAR. REFLEXUM.	PROTEACEAE
@	#	2036000	04600	LEUCOSPERMUM TRUNCATULUM (SALISB.EX KNIGHT) ROURKE.	PROTEACEAE
@	#	2036000	99999	LEUCOSPERMUM SP.	PROTEACEAE
@	#	2037000	00200	LEUCODENDRON ARCUATUM (LAM.) I.WILLIAMS	PROTEACEAE
@	#	2037000	00700	LEUCODENDRON BRUNIOIDES I.WILLIAMS	PROTEACEAE
@	#	2037000	01000	LEUCODENDRON CHAMELAEA (LAM.) I.WILLIAMS	PROTEACEAE
@	#	2037000	01600	LEUCODENDRON CONIFERUM (L.)MEISN.	PROTEACEAE
@	#	2037000	02100	LEUCODENDRON DAPHNOIDES	PROTEACEAE
@	#	2037000	02500	LEUCODENDRON DUBIUM (BUEK.EX MEISN.) PHILL.& HUTCH.	PROTEACEAE
@	#	2037000	03700	LEUCODENDRON GLABERRIMUM (SCHLTR.) COMPTON	PROTEACEAE
@	#	2037000	04900	LEUCODENDRON LORANTHIFOLIUM (SALISB.EX KNIGHT) I.WILLIAMS	PROTEACEAE
@	#	2037000	05700	LEUCODENDRON NITIDA BUEK EX MEISN.	PROTEACEAE
@	#	2037000	06200	LEUCODENDRON PUBESCENS R.BR.	PROTEACEAE
@	#	2037000	06800	LEUCODENDRON RUBRUM BURM. F.	PROTEACEAE
@	#	2037000	07000	LEUCODENDRON SALIGNUM BERG.	PROTEACEAE
@	#	2037000	08100	LEUCODENDRON SPISSIFOLIUM (SALISB.EX KNIGHT.) I.WILLIAMS SUBSP. SPISSIFOLIUM	PROTEACEAE
@	#	2038000	00100	AULAX CANCELLATA (L.) DRUCE.	PROTEACEAE
@	*	2074010	00900	TAPINANTHUS KRAUSIANUS MEISN.V.TIEGHEM.	LORANTHACEAE
@	FH	2074030	00100	MOQUINELLA RUBRA (SPRENG.) BALLE	LORANTHACEAE
	**	2093000	00200	VISCUM CAPENSE	VISCACEAE
@	JS	2093000	00400	VISCUM CONTINUUM	VISCACEAE
	**	2093000	00600	VISCUM ROTUNDIFOLIA	VISCACEAE

@	#	2118000	01900	THESIUM CARINATUM DC. VAR. CARINATUM.	SANTALACEAE
@	#	2118000	07500	THESIUM HISPIDULUM LAM. EX SOND.	SANTALACEAE
@	**	2118000	08500	THESIUM JUNCEUM BERNH.	SANTALACEAE
@	#	2118000	09000	THESIUM IMBRICATUM THUNB.	SANTALACEAE
@	**	2118000	09300	THESIUM LINEATUM L.F.	SANTALACEAE
@	#	2118000	11300	THESIUM ORESIGENUM COMPION.	SANTALACEAE
	*	2118000	11700	THESIUM PANICULATUM L.	SANTALACEAE
@	#	2118000	13100	THESIUM PUBESCENS DC.	SANTALACEAE
@	#	2118000	14900	THESIUM SELAGINEUM DC.	SANTALACEAE
@	#	2118000	15300	THESIUM SPICATUM L.	SANTALACEAE
@	*	2118000	15900	THESIUM SUBNUDUM SOND.	SANTALACEAE
	*	2118000	16400	THESIUM TRIFLORUM THUNB. EX.F.L.F.	SANTALACEAE
@	*	2118000	16900	THESIUM VIRGATUM LAM.	SANTALACEAE
@	#	2118000	99999	THESIUM SP.	SANTALACEAE
@	**	2121000	00500	GRUBBIA ROSMARINIFOLIA	GRUBBIACEAE
	DU	2136000	00300	XIMENIA CAFFRA SONDER.	OLACACEAE
	DU	2201000	00000	POLYGONUM ACUMINATA H.B. ET K.	POLYGONACEAE
@	*	2201000	01600	POLYGONUM MEISERIANUM CHAM & SCHLECHTD.	POLYGONACEAE
@	**	2201000	02000	POLYGONUM SALICIFOLIUM WILLD.	POLYGONACEAE
@	**	2201000	02250	POLYGON SETILOBA WILLD.	POLYGONACEAE
@	**	2201000	99999	POLYGON SP.	POLYGONACEAE
@	*	2201010	00100	BILDERDYKIA CONVULUS (L.) DUMORT	POLYGONACEAE
	DU	2204000	00000	OXYGONUM CALCARATUM BURCH	POLYGONACEAE
@	**	2214000	00300	CHENOPODIUM AMBROSOIDES L.	CHENOPODIACEAE
	DU	2214000	00000	SPINACIA OLERACEA L.	CHENOPODIACEAE
@	JS	2226000	00100	EXOMIS MICROPHYLLA (THUNB.) AELL.	CHENOPODIACEAE
	DU	2229000	00000	ATRIPLEX FARINOSA FORSK.	CHENOPODIACEAE
@	**	2240000	00300	KOCHIA PUBESCENS MOQ.	CHENOPODIACEAE
@	**	2269000	00800	SALSOLA APHYLLA L.F.	CHENOPODIACEAE
@	**	2269000	99999	SALSOLA SP.	CHENOPODIACEAE
	DU	2270000	00000	POLYCNEMUM CORYMBOSA LINN.	CHENOPODIACEAE
	DU	2287000	00200	LOPHIOCARPUS POLYSTACHYUS TURCZ.	CHENOPODIACEAE
	DU	2287000	00300	LOPHIOCARPUS TENUISSIMUS HOOK. F.	CHENOPODIACEAE
@	**	2293000	00300	HERMBSTAEDTIA GLAUCA (WENDL.) REICHB. EX STENDEL	AMARANTHACEAE
@	**	2299000	01300	AMARANTHUS THUNBERGII MOQ.	AMARANTHACEAE
	DU	2308000	00400	MARCELLIA BAINESII C.B.CL.	AMARANTHACEAE
	DU	2309010	00100	CENTEMOPSIS RUBRA (LAPR.) SCHINZ.	AMARANTHACEAE
	DU	2309010	00000	CENTEMOPSIS GRACILENTA (HIERN.) SCHINZ	AMARANTHACEAE
	DU	2314000	00100	PUPALIA ATROPURPUREA D.C.	AMARANTHACEAE
	DU	2314000	00200	PUPALIA LAPPACEAE JUSS.	AMARANTHACEAE
	DU	2324000	00100	PSILOTRICHIUM AFRICANUM OLIV.	AMARANTHACEAE
	DU	2324000	00200	PSILOTRICHIUM SCLERANTHUM THW.	AMARANTHACEAE
	DU	2324000	00000	PSILOTRICHIUM SCHIMPERI ENGL.	AMARANTHACEAE
	DU	2324000	00000	PSILOTRICHIUM SCLERANTHUM THW.	AMARANTHACEAE
	DU	2325000	00200	CALICOREMA SQUARROSA (SCHINZ.) SCHINZ.	AMARANTHACEAE
	DU	2339000	00000	PHILOXERUS VERMICULARIS (L.) R. BR.	AMARANTHACEAE
	DU	2343000	00000	BOUGAINVILLEA SPECTABILIS WILLD.	NYCTAGINACEAE
	DU	2374000	00400	ADENOGRAMMA GLOMERATA (L.F.) DRUCE	AIZOACEAE
@	#	2374000	00700	ADENOGRAMMA MOLLUGA REICHB.F.	AIZOACEAE
	#	2375000	00100	POLPODA CAPENSIS PRESL.	AIZOACEAE
@	**	2376000	00100	LIMEUM AETHIOPICUM	AIZOACEAE
	DU	2376000	00600	LIMEUM AFRICANUM L.	AIZOACEAE
	DU	2376000	01000	LIMEUM ARGUTE N.E.BR.	AIZOACEAE
	DU	2376000	01400	LIMEUM FENESTRATUM (FENZL.) HIEMERL.	AIZOACEAE
	DU	2379000	00700	PSAMMOTROPHA MUCRONATA THUNB.	AIZOACEAE
	*	2387000	00100	MOLLUGO CERVIANA (L.) SER.EX.DC.	AIZOACEAE
@	#	2389000	01000	PHARNACEUM ELONGATUM (DC.) ADAMSON.	AIZOACEAE

@	#	2389000	01500	PHARNACEUM LINEARE BARTL.	AIZOACEAE
@	#	2389000	01900	PHARNACEUM SERRYLLIFOLIUM L.F.	AIZOACEAE
@	**	2389000	99999	PHARNACEUM SP.	AIZOACEAE
@	**	2399000	01500	GALENIA FRUTICOSA (L.F.)SOND.VAR.FRUTICOSA.	AIZOACEAE
@	JS	2399000	03400	GALENIA SARCOPHYLLA	AIZOACEAE
@	#	2400000	00200	ACROSANTHES ANGUSTIFOLIA ECKL. & ZEYH.	AIZOACEAE
@	**	2402000	99999	AIZOON SP.	AIZOACEAE
@	**	2403000	02250	TETRAGONIA ORBUSCULA	AIZOACEAE
@	**	2403000	02650	TETRAGONIA ROBUSTA FENZL.	AIZOACEAE
@	**	2403000	03300	TETRAGONIA SPICATA L.F.	AIZOACEAE
@	**	2405009	00100	APTENIA CORDIFOLIA SCHWANT.	AIZOACEAE
@	#	2405030	21900	CONOPHYTUM OBCONELLUM (HAW.) SCHWANT.	MESEMBRYANTHEMACEAE
@	#	2405033	99999	DELOSPERMA SP.	MESEMBRYANTHEMACEAE
@	#	2405039	01000	DOROTHEANTHUS HALLII L.BOL.	MESEMBRYANTHEMACEAE
@	JS	2405042	00800	EBERLANZIA FEROX	MESEMBRYANTHEMACEAE
@	#	2405066	03300	LAMBRANTHUS CARILLACEUS (L.BOL.) N.E.BR.	MESEMBRYANTHEMACEAE
@	JS	2405066	03500	LAMBRANTHUS CEDERBERGENSIS L.BOL	MESEMBRYANTHEMACEAE
@	#	2405066	11800	LAMBRANTHUS LEPTOSEPHALUS (L.BOL.) L.BOL.	MESEMBRYANTHEMACEAE
@	#	2405066	21700	LAMBRANTHUS TULBAGHENSIS (BERGER) L.BOL.	MESEMBRYANTHEMACEAE
@	**	2405071	00250	MALEPHORA CROCEA (JACQ.) SCHWANT.	MESEMBRYANTHEMACEAE
	*	2405071	01100	MALEPHORA MOLLLIS (AIT.)N.E.BR.	MESEMBRYANTHEMACEAE
@	**	2405073	99999	MESEMBRYANTHEMUM SP.	MESEMBRYANTHEMACEAE
@	**	2405101	07400	PSILOCAULON VANDEREITEI	MESEMBRYANTHEMACEAE
@	*	2405101	99999	PSILOCAULON SP.	MESEMBRYANTHEMACEAE
@	#	2405105	29800	RUSCHIA SCHOLLII (SALM-DYCK.) SCHWANT. VAR. SCHOLLII.	MESEMBRYANTHEMACEAE
@	#	2405105	30000	RUSCHIA PARVIFLORA L.BOL.	MESEMBRYANTHEMACEAE
@	#	2405105	31000	RUSCHIA PAUCIFLORA L.BOL.	MESEMBRYANTHEMACEAE
@	#	2405105	34100	RUSCHIA TUMIDULA (HAW.) SCHWANT.	MESEMBRYANTHEMACEAE
@	**	2405105	34650	RUSCHIA UNICELLA	MESEMBRYANTHEMACEAE
@	**	2405105	99999	RUSCHIA SP.	MESEMBRYANTHEMACEAE
@	#	2412000	02500	ANACAMPSEROS TELEPHIASTRUM DC.	PORTULACACEAE
	DU	2424000	00100	BASELLA PANUCULATA	BASELLACEAE
	DU	2449000	00000	SPERGULA NAMAQUENSIS WHTTI	CARYOPHYLLACEAE
	*	2467000	99999	POLLICHIA SP.	ILLECEBRACEAE
@	**	2483000	00100	SCLERANTHUS ANNUUS	ILLECEBRACEAE
@	#	2490000	00600	SILENE GALLICA L.	CARYOPHYLLACEAE
@	*	2490000	01400	SILENE UNDULATA	CARYOPHYLLACEAE
	TH	2490000	01400	SILENE UNDULATA	CARYOPHYLLACEAE
@	#	2502000	01800	DIANTHUS THUNBERGII HOOPER	CARYOPHYLLACEAE
@	*	2541000	00100	ANEMONE CAFFRA ECKL. & ZEYH.	RANUNCULACEAE
	DU	2541000	00000	ANEMONE PATENS L.	RANUNCULACEAE
@	#	2541010	00350	KNOWLTONIA CORDATA H.RASM.	RANUNCULACEAE
	DU	2546000	00000	RANUNCULUS RECURVATUS POIR.	RANUNCULACEAE
@	**	2546000	00400	RANUNCULUS MULTIFIDUS FORSSK.	RANUNCULACEAE
@	**	2759010	00100	XYMALOS MONOSPORA (HARV.)BAILL.	LAURALACEAE
@	**	2853000	00100	PAPAVER ACULACEUM THUNB.	PAPAVERACEAE
@	#	2858010	99999	PHACOCAPNOS SP.	FUMARIACEAE
@	#	2858020	00100	CYSTICAPNOS VESICARIUS (L.) FEDDE.	FUMARIACEAE
@	#	2862000	00100	TRIGONOCAPNOS CURVIRES SCHLTR.	FUMARIACEAE
@	#	2875000	00350	HELIOPHILA AFRICANA (L.)MARAIS	BRASSICACEAE
@	**	2875000	00500	HELIOPHILA AMPLEXICAULIS L.F.	BRASSICACEAE
@	#	2875000	00600	HELIOPHILA ARENARIA SOND. VAR. ACOCKSII MARIAS	BRASSICACEAE
@	#	2875000	01000	HELIOPHILA ARENOSA SCHLTR.	BRASSICACEAE
@	#	2875000	02000	HELIOPHILA CORNUTA SOND. VAR. CORNUTA.	BRASSICACEAE
@	#	2875000	02100	HELIOPHILA CORNUTA SOND. VAR. SQUAMATA (SCHLTR.) MARAIS	BRASSICACEAE
@	#	2875000	02200	HELIOPHILA CORONOPIFOLIA L.	BRASSICACEAE
@	#	2875000	03000	HELIOPHILA DREGEANA SOND.	BRASSICACEAE

@	*	2875000	03300	HELIOPHILA ELONGATA (THUNB.) DC.	BRASSICACEAE
@	#	2875000	05500	HELIOPHILA NAMAQUANA H.BOL.	BRASSICACEAE
@	*	2875000	07100	HELIOPHILA RIGIDULISCULA SOND.	BRASSICACEAE
@	#	2875000	07500	HELIOPHILA SCOPARIA BURCH. VAR.ASPERA (SCHLTR.)MARAIS	BRASSICACEAE
@	#	2875000	07800	HELIOPHILA SESELIFOLIA BURCH. EX DC. VAR. NIGELLIFOLIA (SCHLTR.) MARIAS.	BRASSICACEAE
@	#	2875000	99999	HELIOPHILA SP.	BRASSICACEAE
@	#	2877000	00100	BRACHYCARPAEA JUNCEA (BERG.)MARAIS	BRASSICACEAE
	DU	2877000	00000	BRACHYCARPAEA VARIANS DC.	BRASSICACEAE
@	#	2878000	00100	CYCLOPTYCHIS MARLOTHII O.E. SCHULZ.	BRASSICACEAE
@	**	2917000	00100	SISYMBRIUM BURCHELLI DC.	BRASSICACEAE
	DU	2917000	00700	SISYMBRIUM OFFICINALE (L.) SCOP.	BRASSICACEAE
	DU	2949000	00100	BRASSICA JUNCEA (L.) COSSON	BRASSICACEAE
	DU	3082000	00000	CALYPTROTHECA TAITENSIS (PAX & VATKE.) BRENNAN	CAPPARIDACEAE
	DU	3101000	00000	CAPPARIS ERYTHROCARPOS ISERT	CAPPARIDACEAE
	DU	3101000	00000	CAPPARIS ROSEA (KLOTZSCH.) OLIV.	CAPPARIDACEAE
	DU	3106000	00000	BOSCIA CORYMBOSA GILG.	CAPPARIDACEAE
	DU	3106000	00000	BOSCIA MOSSAMBICENSIS KLOTZSCH.	CAPPARIDACEAE
@	JS	3109000	00100	CADABA APHYLLA (THUNB.) WILLD.	CAPPARIDACEAE
	DU	3109000	00000	CADABA KIRKII OLIV.	CAPPARIDACEAE
	DU	3109000	00000	CADABA MIRABILIS GILG.	CAPPARIDACEAE
	DU	3109000	00400	CADABA TERMITARIA N.E.BR.	CAPPARIDACEAE
	DU	3112000	00000	MAERUA MASCHONICA GILG.	CAPPARIDACEAE
	DU	3112000	00900	MAERUA PARVIFLORA PAX.	CAPPARIDACEAE
	DU	3114000	00000	RITCHICA ENGLERIANA BUSC. & MUSCHL.	CAPPARIDACEAE
@	#	3138000	00100	RORIDULA DENTATA L.	DROCERACEAE
@	**	3164000	00950	COTYLEDON CUNEATA THUNB.	CRASSULACEAE
@	**	3164000	03200	COTYLEDON ORBISCULA L.	CRASSULACEAE
@	**	3164000	03400	COTYLEDON PAPILLARIS L.F.	CRASSULACEAE
	**	3164000	04800	COTYLEDON TOMENTOSUM HARV.	CRASSULACEAE
@	#	3164010	02900	TYLECODON WALLICHII (HARV.) TOELKEN. SUBSP. WALLICHI	CRASSULACEAE
@	#	3164010	02700	TYLECODON VENTRICOSUS (BURM.F.)TOELKEN	CRASSULACEAE
@	#	3164010	01600	TYLECODON RETICULATIS L.F.O.TOELKEN SUBSP. TOELKEN.	CRASSULACEAE
@	#	3168000	01400	CRASSULA APHYLLA SCHONL.& BAK.F.	CRASSULACEAE
@	#	3168000	02300	CRASSULA ATROPUPPUREA (HAW.) DIETR. VAR. PURCELLII.(SCHONL.) TOELKEN	CRASSULACEAE
@	**	3168000	03000	CRASSULA BARBATA THUNB. SUBSP. BARBATA	CRASSULACEAE
@	**	3168000	09000	CRASSULA CAPITELLA THUNB.	CRASSULACEAE
@	#	3168000	08000	CRASSULA CORALLINA THUNB.SUBSP.CORALLINA.	CRASSULACEAE
@	**	3168000	09000	CRASSULA DECENDENS THUNB.	CRASSULACEAE
@	FH	3168000	09600	CRASSULA DEPENDENS H.BOL.	CRASSULACEAE
@	*	3168000	09700	CRASSULA EXPANSE DRYLAND SUBSP. NUDICAULIS	CRASSULACEAE
@	#	3168000	10000	CRASSULA MONTANA THUNB. SUBSP. QUADRANGULARIS (SCHONL.) TOELKEN.	CRASSULACEAE
@	*	3168000	11600	CRASSULA NUDICAULIS L.	CRASSULACEAE
@	*	3168000	21200	CRASSULA OVATA (MILL.) DRUCE	CRASSULACEAE
	*	3168000	22300	CRASSULA PAPILLOSA SCHONL.& BAK.F.	CRASSULACEAE
@	*	3168000	25000	CRASSULA RAMULIFOLIA	CRASSULACEAE
	TH	3168000	25000	CRASSULA RAMULIFOLIA	CRASSULACEAE
@	#	3168000	26700	CRASSULA RUPESTRIS THUNB. SUBSP.RUPESTRIS	CRASSULACEAE
@	#	3168000	27400	CRASSULA SCABRA L.	CRASSULACEAE
	**	3168000	28900	CRASSULA SETULOSA HARV. VAR. SETULOSA	CRASSULACEAE
@	**	3168000	32700	CRASSULA TOMENTOSA THUNB.	CRASSULACEAE
@	*	3168000	32750	CRASSULA TRACHYSANTHA	CRASSULACEAE
@	#	3168000	33100	CRASSULA UMBELLA JACQ.	CRASSULACEAE
@	#	3168000	33200	CRASSULA UMBELLATA THUNB.	CRASSULACEAE
	TH	3168000	33300	CRASSULA UMBRATICULA	CRASSULACEAE

	DU	3169000	00000	SEDUM PUSILLUM MICHX.	CRASSULACEAE
@	#	3175000	00500	ADROMISCHUS HUMILIS (MARLOTH) V.POELLN.	CRASSULACEAE
@	*	3175000	03600	ADROMISCHUS RHOMBIFOLIUS (HAW.)LEM.EX. BURGER	CRASSULACEAE
@	#	3238000	00100	MONTINIA CARYOPHYLLACEAE THUNB.	MONTINIACEAE
@	#	3285000	00400	TITIMANNIA LAXA (THUNB.) PRESL.VAR.LAXA.	BRUNIACEAE
@	#	3288000	00500	RASPALIA MICROPHYLLA	BRUNIACEAE
@	#	3291000	00100	PSEUDOBAECKEA CORDATA (BURM.F) PILLANS	BRUNIACEAE
@	#	3294000	01100	BERZELIA LANUGINOSA (L.) BRONGN.	BRUNIACEAE
	DU	3295000	00000	HAMAMELIS VIRGINANA	HAMAMELIDACEAE
@	**	3311000	00200	TRICHOCLADUS ELLYPTICA ECKL.& ZEYH.	HAMAMELIDACEAE
@	**	3353000	00900	RUBUS LUDWIGII ECKL.& ZEYH.	ROSACEAE
@	**	3353000	01250	RUBUS RIGIDUS SM.	ROSACEAE
	DU	3353000	00000	RUBUS STEUDNERI SCHWEINF.	ROSACEAE
@	*	3365000	00100	GEUM CAPENSE THUNB.	ROSACEAE
	*	3375000	99999	ALCHEMILLA SP.	ROSACEAE
	TH	3379000	00100	LEUCOSIDEA SERICEA	ROSACEAE
@	#	3388000	00500	CLIFFORTIA AMPLEXISTIPULA SCHLTR.	ROSACEAE
@	JS	3388000	00700	CLIFFORTIA ARBOREA	ROSACEAE
@	#	3388000	02850	CLIFFORTIA DREGEANA PRESL. VAR.MEYERIANA (PRESL.) WEIM	ROSACEAE
@	#	3388000	03500	CLIFFORTIA FACATA L.F.	ROSACEAE
@	#	3388000	08200	CLIFFORTIA PROPINQUA ECKL.& ZEYH.VAR.PROPINQUA	ROSACEAE
@	#	3388000	09100	CLIFFORTIA RUSCIFOLIA L.VAR.RUSCIFOLIA	ROSACEAE
@	*	3388000	09400	CLIFFORTIA SERPHYLLIFOLIA CHAM.& SCHLECHT.	ROSACEAE
@	#	3388000	10200	CLIFFORTIA TERETIFOLIA L.F.	ROSACEAE
@	#	3388000	10600	CLIFFORTIA TUBERCULATA (HARV.) WEIM. VAR. TUBERCULATA	ROSACEAE
@	#	3388000	10700	CLIFFORTIA UNCINATA WEIM. VAR.UNCINATA	ROSACEAE
	DU	3396000	00100	PRINUS AFRICANA (HOOK.F.) KALKN.	ROSACEAE
	DU	3446000	90500	ACACIA BREVISPICA HARMS.	FABACEAE
	DU	3446000	91150	ACACIA ETHAICA SCHWEIN.	FABACEAE
@	JS	3446000	92300	ACACIA KAROO HAYNE	FABACEAE
	DU	3446000	00000	ACACIA NUBICA BENTH.	FABACEAE
@	**	3454000	00100	PROSOPIS GLANDULOSA TORR	FABACEAE
@	**	3460000	00100	NEWTONIA HILDEBRANDTII (VAKTE) TORR	FABACEAE
@	*	3468000	00500	ENTADA SPICATA (E.MEY.) DRUCE	FABACEAE
@	*	3506000	00100	SCHOTIA AFRA (L.) THUNB.	FABACEAE
@	*	3536000	01000	CASSIA CAPENSIS THUNB.	FABACEAE
	DU	3536000	00000	CASSIA LONGIRACEMOSA VATKE.	FABACEAE
	DU	3536000	00000	CASSIA OCCIDENTALIS L.	FABACEAE
@	*	3607000	00100	CALPURNIA AURA (AIT.) BENTH.	FABACEAE
@	*	3607000	00300	CALPURNIA FLORISBUNDA HARV.	FABACEAE
	DU	3621000	01000	PODALYRIA GLAUCA DC.	FABACEAE
@	#	3621000	01800	PODALYRIA PEARSONII PHILL.	FABACEAE
@	KI	3643000	01800	PRIESTLEYA UMBELLIFERA DC.	FABACEAE
@	#	3643000	99999	PRIESTLEYA SP.	FABACEAE
@	#	3646000	00110	COELIDIUM CEDARBERGENSIS GRANDBY	FABACEAE
@	#	3646000	00850	COELIDIUM VILLOSUM (SCHLTR.) GRANDBY	FABACEAE
@	#	3646000	00100	COELIDIUM BOWEI BENTH.	FABACEAE
@	#	3654000	00200	RAFNIA AMPLEICAULIS THUNB.	FABACEAE
@	#	3654000	00500	RAFNIA CAPENSIS (L.) DRUCE	FABACEAE
@	#	3654000	00800	RAFNIA DICHOTOMA ECKL.& ZEYH.	FABACEAE
@	#	3654000	01300	RAFNIA OPPOSITIA THUNB.	FABACEAE
@	#	3654000	01400	RAFNIA OVATA E.MEY.	FABACEAE
@	#	3654000	01800	RAFNIA SPICATA THUNB.	FABACEAE
@	#	3654000	01900	RAFNIA TRIFLORA THUNB.	FABACEAE
	TH	3657000	02200	LOTONONIS CORYMBOSA	FABACEAE
@	*	3657000	02500	LOTONONIS CYTISOIDES BENTH	FABACEAE
@	JS	3657000	04500	LOTONONIS HUMIFUSA BURCH.EX BENTH.	FABACEAE

@	*	3657000	08000	LOTONONIS PUNGENS ECKL. & ZEYH.	FABACEAE
@	#	3660000	00600	LEBECKIA CYTISOIDES THUNB.	FABACEAE
@	#	3660000	03000	LEBECKIA SIMSIANA ECKL.& ZEYH.	FABACEAE
@	#	3661000	00800	WIBORGIA SERICEA THUNB.	FABACEAE
@	#	3661000	01000	WIBORGIA TETRAPTIA E.MEY.	FABACEAE
@	#	3662000	02000	ASPALATHUS ALTISSIMA DAHLG.	FABACEAE
@	#	3662000	03900	ASPALATHUS BODKINII H.BOL.	FABACEAE
@	#	3662000	04200	ASPALATHUS BRACTEATA THUNB.	FABACEAE
@	#	3662000	06800	ASPALATHUS COMPTONII DAHLG.	FABACEAE
@	*	3662000	07400	ASPALATHUS CORRUNDIFOLIA BERG.	FABACEAE
@	#	3662000	07500	ASPALATHUS COSTULATA BENTH.	FABACEAE
@	#	3662000	08200	ASPALATHUS DECORA DAHLG.	FABACEAE
@	*	3662000	08300	ASPALATHUS DESERTORUM	FABACEAE
@	#	3662000	08750	ASPALATHUS DIVARICATA THUB.SUBSP.BREVICARPA DAHLG.	FABACEAE
@	#	3662000	08800	ASPALATHUS DIVARICATA THUNB.SUBSP.DIVARICATA	FABACEAE
@	#	3662000	09800	ASPALATHUS FLEXUOSA THUNB.	FABACEAE
@	#	3662000	10500	ASPALATHUS GALEATA E.MEY.	FABACEAE
@	#	3662000	11700	ASPALATHUS HIRTA E.MEY.SUBSP.HIRTA.	FABACEAE
@	#	3662000	11800	ASPALATHUS HISPIDA THUNB.SUBSP.HISPIDA	FABACEAE
@	#	3662000	13600	ASPALATHUS LANATA E.MEY.	FABACEAE
@	#	3662000	13800	ASPALATHUS LANCEIFOLIA DAHLG.	FABACEAE
@	#	3662000	13900	ASPALATHUS LANIFERA DAHLG.	FABACEAE
@	#	3662000	14600	ASPALATHUS LINEARIS (BURM.F.) DAHLG. SUBSP. LINEARIS	FABACEAE
@	#	3662000	17700	ASPALATHUS PENDULA DAHLG.	FABACEAE
@	#	3662000	18350	ASPALATHUS POLYCEPHALA E.MEY. SUBSP. LANATIFOLIA DAHLG.	FABACEAE
@	#	3662000	18400	ASPALATHUS POLYCEPHALA E.MEY.SUBSP. POLYCEPHALA	FABACEAE
@	#	3662000	19250	ASPALATHUS QUINQUIFOLIA L.SUBSP.ACOCKSII DAHLG.	FABACEAE
@	#	3662000	19300	ASPALATHUS QUINQUIFOLIA L.SUBSP.QUINQUIFOLIA	FABACEAE
@	*	3662000	20700	ASPALATHUS RUBIGINOSA DAHLG.	FABACEAE
@	*	3662000	21950	ASPALATHUS SIMII	FABACEAE
@	#	3662000	22400	ASPALATHUS SPICATA THUNB. SUBSP.SPICATA	FABACEAE
@	#	3663000	22800	ASPALATHUS SPINOSISSIMA DAHLG. SUBSP. SPINOSISSIMA	FABACEAE
@	#	3662000	23950	ASPALATHUS TRIDENTATA L.SUBSP.FRAGILIS DAHLG.	FABACEAE
@	#	3662000	23970	ASPALATHUS TRIDENTATA L.SUBSP.ROTUNDA DAHLG.	FABACEAE
@	#	3662000	24000	ASPALATHUS TRIDENTATA L.SUBSP.TRIDENTATA	FABACEAE
@	#	3662000	24100	ASPALATHUS TRIQUETRA THUNB.	FABACEAE
@	#	3662000	25300	ASPALATHUS VILLOSA THUNB.	FABACEAE
@	#	3662000	25400	ASPALATHUS VULNERANS THUNB.	FABACEAE
@	KI	3662000	25700	ASPALATHUS WORMBEANA E.MEY.	FABACEAE
	**	3663000	00500	BUCHENROEDERA MULTIFLORA ECKL.& ZEYH.	FABACEAE
	**	3665000	00955	MELOLOBIUM CANDICANS (E.MEY.) ECKL.& ZEYH.	FABACEAE
	DU	3665000	01200	MELOLOBIUM MICROPHYLLUM (THUNB.) ECKL. & ZEYH.	FABACEAE
	*	3665000	01300	MELOLOBIUM INVOLUCRATUM BENTH.	FABACEAE
@	**	3665000	01300	MELOLOBIUM OBCORDATUM HARV.	FABACEAE
	DU	3669000	00000	CROTALARIA AXULLARIS AIT.	FABACEAE
@	*	3673000	01300	ARGYROLOBIUM LANCEOLATUM ECKL.& ZEYH.	FABACEAE
	TH	3673000	01500	ARGYROLOBIUM MARGINATUM	FABACEAE
@	*	3673000	01700	ARGYROLOBIUM MOLLE ECKL. & ZEYH.	FABACEAE
@	*	3673000	02300	ARGYROLOBIUM PATENS ECKL.& ZEYH	FABACEAE
@	*	3673000	02400	ARGYROLOBIUM PAUCIFLORUM ECKL. & ZEYH.	FABACEAE
@	*	3673000	03400	ARGYROLOBIUM SPECIOSUM ECKL.& ZEYH	FABACEAE
	TH	3673000	03600	ARGYROLOBIUM SUTHERLANDII	FABACEAE
@	*	3673000	03700	ARGYROLOBIUM TOMENTOSUM (ANDR.) DRUCE	FABACEAE
	TH	3673000	03900	ARGYROLOBIUM TUBEROSUM	FABACEAE
@	JS	3673000	99999	ARGYROLOBIUM SP.	FABACEAE
@	**	3690000	00100	TRIFOLIUM AFRICANUM SER.	FABACEAE
@	JS	3690000	00700	TRIFOLIUM BURCHELLIANUM SER.	FABACEAE

@	#	3702000	00300	INDIGOFERA ADENOIDES BAK.F.	FABACEAE
@	#	3702000	00800	INDIGOFERA AMOENA AIT.	FABACEAE
@	*	3702000	04800	INDIGOFERA CUNEIFOLIA ECKL.& ZEYH.	FABACEAE
@	JS	3702000	07900	INDIGOFERA DENUDATA THUNB.	FABACEAE
@	**	3702000	08900	INDIGOFERA FASTIGIATA E.MEY.	FABACEAE
@	*	3702000	10600	INDIGOFERA HETEROPHYLLA THUNB.	FABACEAE
@	*	3702000	11600	INDIGOFERA HUMIFUSA ECKL.& ZEYH.	FABACEAE
	DU	3702000	00000	INDIGOFERA HOMBEI BAK.F. & MARTIN.	FABACEAE
@	**	3702000	19500	INDIGOFERA SESSIFOLIA DC.	FABACEAE
	DU	3702000	20870	INDIGOFERA SWAZIENSIS BALUS.	FABACEAE
@	#	3702000	99999	INDIGOFERA SP.	FABACEAE
@	#	3703000	00400	PSORALEA APHYLLA L.	FABACEAE
	DU	3703000	00000	PSORALEA FALIOSA OLIV.	FABACEAE
@	#	3703000	02900	PSORALEA OLIGOPHYLLA ECKL.& ZEYH.	FABACEAE
@	#	3703000	03000	PSORALEA PINNATA L.	FABACEAE
@	*	3703000	03100	PSORALEA POLYPHYLLA ECKL.& ZEYH.	FABACEAE
@	#	3703000	04400	PSORALEA TRIANTHA E.MEY.	FABACEAE
@	*	3718000	01200	TEPHROSIA CAPENSIS (JACQ.) PERS	FABACEAE
	DU	3718000	04200	TEPHROSIA LINEARIS (WILLD.) PERS.	FABACEAE
	TH	3718000	04800	TEPHROSIA MARGINELLA	FABACEAE
	DU	3747000	00000	SESBANIA DUMMERI PHILL. & HUTCH.	FABACEAE
	DU	3747000	00000	SESBANIA GREENWAYII GILLETT	FABACEAE
	TH	3756000	03800	LESSERTIA PERENNANS	FABACEAE
@	**	3756000	04100	LESSERTIA PHYSOIDES ECKL.&ZEYH.	FABACEAE
@	*	3810000	00200	ALYSICARPUS RUGOSUS (WILLD.) DC.	FABACEAE
	DU	3810000	00300	ALYSICARPUS RUGOSUS (WILLD.) DC.	FABACEAE
@	#	3852000	00300	VICIA SATIVA L.	FABACEAE
@	JS	3870000	99999	ERYTHRINA SP.	FABACEAE
	*	3897000	01000	RHYNCOSIA CALVESCENS MEIKLE	FABACEAE
@	*	3897000	01500	RHYNCOSIA CILIATA (THUNB.) SCHINNZ	FABACEAE
@	**	3897000	04200	RHYNCOSIA MINIMA (L.) DC.	FABACEAE
@	*	3897000	04600	RHYNCOSIA NERVOSA BENTH. HARV	FABACEAE
@	*	3897000	02100	VIGNA VEXILLATA (L.) A.RICH.	FABACEAE
	DU	3898000	00000	ERIOSOMA GLOMERATUM (GUILL. EX. PERR.) HOOK.F.	FABACEAE
	DU	3910000	00000	DOLICHOS BUCHANII HARMS.	FABACEAE
@	DU	3897000	08000	DOLICHOS HASTAEFORMIS	FABACEAE
	DU	3920000	00000	DELONIX ELATA (L.) GAMBLE	FABACEAE
@	*	3924000	00200	GERANIUM CAFFRUM ECKL.& ZEYH	GERANIACEAE
	TH	3924000	01300	GERANIUM ORNITHOPODIUM	GERANIACEAE
@	*	3924000	01400	GERANIUM ORNITHOPODIUM ECKL.& ZEYH.	GERANIACEAE
	TH	3924000	09700	GERANIUM LURIDUM	GERANIACEAE
@	*	3925000	00850	MONSONIA EMARGINATA (L.F.) L'HERIT	GERANIACEAE
	DU	3926000	00500	SARCOCAULON MOSSAMBEDENSIS (WELW.)	GERANIACEAE
	DU	3926000	01200	SARCOCAULON RIGIDUM SCHZ.	GERANIACEAE
@	**	3928000	00100	PELARGONIUM ABROTANIFOLIUM (L.F.) JACQ.	GERANIACEAE
@	KI	3928000	02550	PELARGONIUM CAESPITOSIUM TURCZ. SUBSP.CONCAVUM HUGO.	GERANIACEAE
@	KI	3928000	03700	PELARGONIUM CHAMAEDRYFOLIUM JACQ.	GERANIACEAE
	#	3928000	03900	PELARGONIUM CORDATUM L.F.	GERANIACEAE
@	#	3928000	04200	PELARGONIUM CORONOPIFOLIUM JACQ. SUBSP. CORONOPIFOLIUM	GERANIACEAE
@	#	3928000	04500	PELARGONIUM CRISPUM (BERG.) L'HERIT	GERANIACEAE
@	**	3928000	06500	PELARGONIUM FUMAROIDES L'HERIT	GERANIACEAE
@	**	3928000	06900	PELARGONIUM GLUTINOSUM (JACQ.) L'HERIT	GERANIACEAE
@	**	3928000	07300	PELARGONIUM GRISEUM KUNTH.	GERANIACEAE
@	JS	3928000	07400	PELARGONIUM GROSSULAROIDES (L.) L'HERIT	GERANIACEAE
@	#	3928000	09100	PELARGONIUM LAEVIGATUM (L.F.) WILLD. SUBSP. LAEVIGATUM.	GERANIACEAE
@	#	3928000	09600	PELARGONIUM LONGIFOLIUM (BURM.F.)JACQ.	GERANIACEAE
@	#	3928000	09770	PELARGONIUM MAGENTEUM J.J.A.V.D.WALT	GERANIACEAE

@	#	3928000	11200	PELARGONIUM OENOTHERA (L.F.)JACQ.	GERANIACEAE
@	**	3928000	12200	PELARGONIUM PATULUM JACQ.	GERANIACEAE
@	*	3928000	12400	PELARGONIUM PELTATUM JACQ.	GERANIACEAE
@	**	3928000	14100	PELARGONIUM RAMISISSIMUM (CAV.) WILLD.	GERANIACEAE
@	*	3928000	14500	PELARGONIUM RENIFORME CURTIS	GERANIACEAE
@	#	3928000	15300	PELARGONIUM SCABRUM (L.)L'HERIT	GERANIACEAE
	*	3928000	14730	PELARGONIUM RIBIFOLIUM JACQ.	GERANIACEAE
	*	3928000	15400	PELARGONIUM SCHIZOPETALUM SWEET.	GERANIACEAE
@	#	3928000	16500	PELARGONIUM TABULARE (L.) L'HERIT	GERANIACEAE
@	#	3928000	17500	PELARGONIUM TRISTE (L.) L'HERIT	GERANIACEAE
@	**	3928000	18200	PELARGONIUM ZONALE (L.) L'HERIT	GERANIACEAE
@	#	3936000	00200	OXALIS ADSPERSA ECKL. & ZEYH.	OXALIDACEAE
@	#	3936000	00600	OXALIS AMBLYODONTA SALTER	OXALIDACEAE
@	*	3936000	02100	OXALIS BOWEI	OXALIDACEAE
@	#	3936000	06100	OXALIS BRACTEATA SAVIGN.	OXALIDACEAE
@	#	3936000	07500	OXALIS FLAVA L.	OXALIDACEAE
@	*	3936000	08300	OXALIS GLABRA THUNB.	OXALIDACEAE
	DU	3936000	11500	OXALIS LATIFOLIA H.B. & K.	OXALIDACEAE
	TH	3936000	14800	OXALIS OBLIQUIFOLIA	OXALIDACEAE
@	#	3936000	14900	OXALIS OBTUSA JACQ.	OXALIDACEAE
@	#	3936000	15500	OXALIS PALLENS	OXALIDACEAE
@	#	3936000	18300	OXALIS PURPUREA L.	OXALIDACEAE
@	#	3936000	18700	OXALIS RETICAULIS SOND.	OXALIDACEAE
@	*	3936000	19500	OXLAIS SEMILOBA SOND.	OXALIDACEAE
@	*	3936000	19900	OXALIS SMITHIANA ECKL.& ZEYH.	OXALIDACEAE
	TH	3936000	19900	OXALIS SMITHIANA ECKL.& ZEYH.	OXALIDACEAE
@	*	3945000	00100	LINUM AFRICANUM L.	LINACEAE
@	**	3945000	00400	LINUM THUNBERGII ECKL.& ZEYH.	LINACEAE
	TH	3945000	00400	LINUM THUNBERGII ECKL.& ZEYH.	LINACEAE
	DU	3956010	00000	NECTAROPETALUM CONGOLENSE S.MOORE	LINACEAE
@	**	3965000	00450	ZYGOPHYLLUM DEBILE CHAM.& SCHLECHTD.	ZYGOPHYLLACEAE
@	**	3965000	00900	ZYGOPHYLLUM FOETIDUM SCHRAD.& WENDL.	ZYGOPHYLLACEAE
	DU	3965000	00100	ZYGOPHYLLUM INCRUSTATUM E.MEY.	ZYGOPHYLLACEAE
@	**	3965000	01500	ZYGOPHULLUM LICHTENSTEINUM CHAM & SCHLECHTD.	ZYGOPHYLLACEAE
@	**	3965000	02000	ZYGOPHULLUM MICROCARPUM LICHT & CHAM	ZYGOPHYLLACEAE
@	#	3965000	07000	ZYGOPHYLLUM PULVUM L.	ZYGOPHYLLACEAE
@	#	3965000	02550	ZYGOPHYLLUM SESSILIFOLIUM L.	ZYGOPHYLLACEAE
@	*	3965000	02800	ZYGOPHYLLUM SPINOSUM L.	ZYGOPHYLLACEAE
	**	3965000	03300	ZYGOPHYLLUM UITENHAGENSE SOND.	ZYGOPHYLLACEAE
@	*	3978000	00400	TRIBULUS TERRRISTRIS L.	ZYGOPHYLLACEAE
@	#	3980000	00000	BALANITES GLABRA MILDBR. ET. SCHLT.	BALANITACEAE
	DU	3980000	00000	BALANITES PANICULATA	BALANITACEAE
	DU	4037000	00400	AGATHOSMA ADENANDRIFLORA	RUTACEAE
@	#	4037000	00900	AGATHOSMA ALPINA SCHLTR.	RUTACEAE
@	#	4037000	01000	AGATHOSMA ALTICOLA SCHLTR.EX DUEMMER	RUTACEAE
@	#	4037000	01500	AGATHOSMA BATHII (DUEMMER) PILLANS	RUTACEAE
@	#	4037000	01600	AGATHOSMA BETULINA (BERG.) PILLANS	RUTACEAE
@	#	4037000	02000	AGATHOSMA BISULCA (THUNB.) BARTL.& WENDL.	RUTACEAE
@	#	4037000	02200	AGATHOSMA BODKINII DUEMMER	RUTACEAE
@	*	4037000	02300	AGATHOSMA CAPENSIS (L.) DUEMMER	RUTACEAE
@	KI	4037000	03600	AGATHOSMA CRASPEDOTA SOND.	RUTACEAE
@	#	4037000	03800	AGATHOSMA CRENULATA (L.) PILLANS	RUTACEAE
@	#	4037000	04300	AGATHOSMA DIVARICULATA PILLANS.	RUTACEAE
@	#	4037000	04400	AGATHOSMA DREGEANA SOND.	RUTACEAE
@	#	4037000	05500	AGATHOSMA GIFTBERGENSIS PHILL.	RUTACEAE
@	#	4037000	07100	AGATHOSMA KRAKADOUWENSIS DUEMMER.	RUTACEAE
@	#	4037000	07800	AGATHOSMA MARLOTHII DUEMMER	RUTACEAE

@	#	4037000	08000 AGATHOSMA MICROCALYX DUEMMER	RUTACEAE
@	#	4037000	12000 AGATHOSMA SQUAMOSA (ROEM & SCHULTES) BARTL.& WENDL.	RUTACEAE
@	#	4037000	12300 AGATHOSMA STILBEOIDES DUEMMER	RUTACEAE
	**	4037000	13300 AGATHOSMA VENUSTA (ECKL.& ZEYH.) PILLANS	RUTACEAE
@	*	4037000	13400 AGATHOSMA VIRGATA (LAM.) BART.& WENDL.	RUTACEAE
@	#	4037000	99999 AGATHOSMA SP.	RUTACEAE
@	*	4038000	02900 ADENANDRA VILLOSA (BERG.) LICHT.EX ROEM & SCHULTZ	RUTACEAE
@	#	4040000	00500 ACMADENIA BODKINII (SCHLTR.)STRID.	RUTACEAE
@	#	4040000	00900 ACMADENIA FLACCIDA ECKL.& ZEYH.	RUTACEAE
@	#	4040000	01400 ACMADENIA MACRADENIA (SOND.) DUEMMER	RUTACEAE
@	#	4040000	02300 ACMADENIA TERETIFOLIA (LINK.) PHILL.	RUTACEAE
@	#	4040000	99999 ACMADENIA SP.	RUTACEAE
@	#	4041000	00050 DIOSMA ACMAEPHYLLA ECKL.& ZEYH.	RUTACEAE
@	#	4041000	00700 DIOSMA HIRSUTA L.	RUTACEAE
@	#	4041000	00750 DIOSMA MEYERIANA SPRENG.	RUTACEAE
@	#	4042000	00100 PHYLLOSMA CAPENSIS H.BOL.	RUTACEAE
@	#	4043000	00450 EUCHAETIS ELSIEAE I.WILLIAMS	RUTACEAE
@	#	4043000	00490 EUCHAETIS ESTERHUYSENIAE I.WILLIAMS	RUTACEAE
@	#	4043000	00700 EUCHAETIS GLOMERATA BARTL. & WENDL.	RUTACEAE
@	#	4043000	00900 EUCHAETIS LONGIBRACTEATA SCHLTR.	RUTACEAE
@	#	4044000	00300 MACROSTYLIS DECIPIENS E.MEY.EX.SOND.	RUTACEAE
@	#	4044000	00650 MACROSTYLIS RAMULOSA I.WILLIAMS	RUTACEAE
@	#	4044000	00700 MACROSTYLIS SQUARROSA BARTL.& WENDL.	RUTACEAE
@	#	4044000	00800 MACROSTYLIS TENUIS E.MEY.EX. SOND.	RUTACEAE
@	#	4046000	00100 EMPLEURUM UNICAPSULARE (L.F.) SKEELS	RUTACEAE
	DU	4076000	00000 VEPRIS ENGENIIFOLIA (ENGL.) VERD.	RUTACEAE
	**	4091000	00100 CLAUSENIA ANISATA (WILLD.) HOOK F.EX.BENTH	RUTACEAE
	DU	4092010	00000 CITRUS AURANTIFOLIA SWINGLE	RUTACEAE
	DU	4092010	00000 CITRUS RETICULATA VAR. MANDARIN.	RUTACEAE
	DU	4093000	00000 CHOISYA TEONATA (H.B. & K.)	RUTACEAE
	DU	4171000	00100 TURRAEA FLORISBUNDA HOCHST.	RUTACEAE
	DU	4171000	00000 TURRAEA ROBUSTA GUERKE	RUTACEAE
@	#	4273000	00800 POLYGALA BRACHYPHYLLA CHOD.	POLYGALACEAE
@	#	4273000	00900 POLYGALA BRACTEOLATA L.	POLYGALACEAE
	*	4273000	01400 POLYGALA CONFUS MACOWAN	POLYGALACEAE
@	**	4273000	01600 POLYGALA EPHEDROIDES BURCH.	POLYGALACEAE
	*	4273000	02800 POLYGALA HISPIDA BURCH.	POLYGALACEAE
@	**	4273000	02900 POLYGALA HOTTENTTOTTA PRESL.	POLYGALACEAE
@	*	4273000	04300 POLYGALA MICROLOPHA DC.	POLYGALACEAE
@	*	4273000	04500 POLYGALA MYRTIFOLIA	POLYGALACEAE
@	#	4273000	05300 POLYGALA PEDUNCULARIS BURCH.EX DC.	POLYGALACEAE
	*	4273000	05900 POLYGALA PUNGENS BURCH.	POLYGALACEAE
	*	4273000	00740 POLYGALA VIRGATA THUNB. VAR. DECORA	POLYGALACEAE
	TH	4273000	00740 POLYGALA VIRGATA THUNB. VAR. DECORA	POLYGALACEAE
	**	4273000	07500 POLYGALA VIRGATA THUNB. VAR VIRGATA	POLYGALACEAE
@	KI	4273000	99999 POLYGALA SP.	POLYGALACEAE
	DU	4275000	00100 SECURIDACA LONGEPEDUNCULATA FRESEN.	POLYGALACEAE
@	#	4278000	00200 MURALTIA ACACULARIS HARV.	POLYGALACEAE
@	*	4278000	00600 MURALTIA ALOSPECULAROIDES L.DC	POLYGALACEAE
@	*	4278000	00700 MURALTIA ALTICOLA	POLYGALACEAE
@	#	4278000	01600 MURALTIA BRACHYCERAS SCHLTR.	POLYGALACEAE
@	#	4278000	03000 MURALTIA CRASSIFOLIA HARV.	POLYGALACEAE
@	#	4278000	04000 MURALTIA DUMOSA (POIR.) DC.	POLYGALACEAE
@	#	4278000	05200 MURALTIA HEISTERIA (L.) DC.	POLYGALACEAE
@	**	4278000	06600 MURALTIA MACROCARPA ECKL.& ZEYH.	POLYGALACEAE
@	#	4278000	07700 MURALTIA OBOVATA DC.	POLYGALACEAE
@	#	4278000	08700 MURALTIA PILLANSII LEVYNS	POLYGALACEAE

@	#	4278000	09400	MURALTIA RHAMNOIDES CHOD.	POLYGALACEAE
@	#	4279000	00100	NYLANDTIA SPINOSA (L.) DUMORT	POLYGALACEAE
	DU	4295000	00200	PSEUDOLACHNOSTYLIS MAPRENNEAEFOLIA PAX.	EUPHORBIACEAE
	DU	4299000	02300	PHYLLANTHUS RETICULATUS POIR.	EUPHORBIACEAE
	DU	4348000	00200	CROTON GRATISSIMUS BURCH.	EUPHORBIACEAE
	DU	4348000	00800	CROTON PSEUDOPULCHELLUS PAX.	EUPHORBIACEAE
	DU	4368000	00200	ERYTHROCOCCA MENYHARTHII PRAIN.	EUPHORBIACEAE
@	*	4370000	00100	ADENOCLINE ACUTA (THUNB.) BAILL.	EUPHORBIACEAE
	DU	4370000	00000	ADENOCLINE MERCURIALIS TURCZ.	EUPHORBIACEAE
@	*	4370000	00200	ADENOCLINE PAUCIFLORA TURCZ.	EUPHORBIACEAE
	DU	4372000	00200	LEIDESIA PROCUMBENS (L.) PRAIN.	EUPHORBIACEAE
	DU	4388000	00000	ALCHORNEA CAPENSIS MUELL. ARG.	EUPHORBIACEAE
	DU	4388000	00200	ALCHORNEA LASIFLORA (BENTH.) PAX.	EUPHORBIACEAE
	DU	4428000	00200	ALEURITES MOLLUCCANA WILLD.	EUPHORBIACEAE
@	#	4448000	00500	CLUTIA ALATERNOIDES L.VAR.ALATERNOIDES	EUPHORBIACEAE
	DU	4448000	00100	CLUTIA ABYSSINICA JAUB. ET. SPACH.	EUPHORBIACEAE
@	**	4448000	01100	CLUTIA DAPHNOIDES LAM.	EUPHORBIACEAE
@	*	4448000	01500	CLUTIA HETEROPHYLLA THUNB.	EUPHORBIACEAE
@	*	4448000	02000	CLUTIA LAXA ECKL. EX.SOND	EUPHORBIACEAE
	DU	4448000	00000	CLUTIA PAXII KNAUF.	EUPHORBIACEAE
@	#	4448000	02800	CLUTIA POLIFOLIA JACQ.	EUPHORBIACEAE
	DU	4448000	00000	CLUTIA ROBUSTA PAX.	EUPHORBIACEAE
@	**	4448000	04000	CLUTIA THUNBERGII SOND.	EUPHORBIACEAE
@	#	4448000	99999	CLUTIA SP.	EUPHORBIACEAE
	TH	4498000	07600	EUPHORBIA ERICOIDES	EUPHORBIACEAE
@	#	4498000	08000	EUPHORBIA ERYTHRINA LINK.	EUPHORBIACEAE
@	*	4498000	10100	EUPHORBIA GENISTOIDES BERG.	EUPHORBIACEAE
@	**	4498000	13300	EUPHORBIA HYPOGEA MARLOTH.	EUPHORBIACEAE
	DU	4498000	16600	EUPHORBIA MATABELENSIS PAX.	EUPHORBIACEAE
@	**	4498000	17000	EUPHORBIA MAURITANICA L.	EUPHORBIACEAE
@	**	4498000	18500	EUPHORBIA MUNDII N.E.& BR.	EUPHORBIACEAE
@	JS	4498000	21300	EUPHORBIA POLYGONA	EUPHORBIACEAE
@	*	4498000	22000	EUPHORBIA PUGNIFORMIS BOISS.	EUPHORBIACEAE
@	**	4498000	22700	EUPHORBIA RHOMBIFOLIA BOISS.	EUPHORBIACEAE
@	*	4498000	24150	EUPHORBIA SPICYPARISSIUS BOISS.	EUPHORBIACEAE
@	**	4498000	24500	EUPHORBIA STELLAESPINA LAW.	EUPHORBIACEAE
	DU	4508000	00000	ARGOMUELLERA MACROPHYLLA PAX.	EUPHORBIACEAE
	DU	4508000	00000	MANNIOPHYTON AFRICANUM	EUPHORBIACEAE
	DU	4533000	00200	NOTOBUXUS NATALENSIS (OLIV.) HUTCH.	BUXACEAE
@	#	4589000	00100	HEERIA ARGENTEA (THUNB.)MEISN.	ANACARDIACEAE
	DU	4589000	00000	HEERIA RETICULATA ENGL.	ANACARDIACEAE
@	**	4594000	00700	RHUS CARNULOSA SCHONL.	ANACARDIACEAE
@	*	4594000	00800	RHUS CHIRENDENIS BAK.	ANACARDIACEAE
@	#	4594000	01800	RHUS DISSECTA THUNB.	ANACARDIACEAE
@	#	4594000	03400	RHUS INCISA L.F.	ANACARDIACEAE
@	**	4594000	03900	RHUS LANCEA L.F.	ANACARDIACEAE
@	*	4594000	04100	RHUS LONGISPINA	ANACARDIACEAE
@	#	4594000	04200	RHUS LUCIDA L.	ANACARDIACEAE
	TH	4594000	04600	RHUS MACROCARPA	ANACARDIACEAE
@	*	4594000	05900	RHUS PYROIDES BURCH.	ANACARDIACEAE
@	#	4594000	05700	RHUS QUARTINIANA A.RICH.VAR.QUARTINAINA	ANACARDIACEAE
	DU	4594000	05700	RHUS QUARTINIANA A.RICH.VAR.QUARTINAINA	ANACARDIACEAE
@	*	4594000	05900	RHUS REFRACTA ECKL.& ZEYH.	ANACARDIACEAE
@	#	4594000	06100	RHUS RIGIDA MILL.	ANACARDIACEAE
@	#	4594000	06300	RHUS ROSMARINIFOLIA VAHL.	ANACARDIACEAE
@	**	4594000	06550	RHUS SCHLECHTERI DIELS	ANACARDIACEAE
	TH	4594000	07200	RHUS TOMENTOSA	ANACARDIACEAE

@	**	4594000	07400	RHUS UNDULATA JACQ.	ANACARDIACEAE
	DU	4594000	00000	RHUS VULGARIS MEIKLE.	ANACARDIACEAE
@	*	4614000	00200	ILEX AQUIFOLIUM (L.)	AQUIFOLIACEAE
	DU	4614000	00100	ILEX MITIS (L.)	AQUIFOLIACEAE
@	*	4626000	00400	MAYTENUS HETEROPHYLLA L.BOL.	CELASTRACEAE
@	**	4626000	00600	MAYTENUS LUCIDA (L.) LOESS.	CELASTRACEAE
	TH	4626000	00700	MAYTENUS MOSSAMBICENSIS	CELASTRACEAE
@	#	4626000	01000	MAYTENUS OLEOIDES (LAM.) LOES.	CELASTRACEAE
@	*	4626000	01300	MAYTENUS POLYCANTHA (SOND.) MARAIS	CELASTRACEAE
@	**	4626000	01400	MAYTENUS PROCUMBENS (L.F.) LOESS	CELASTRACEAE
	DU	4628000	00200	PUTTERLICHA VERRUEOSA	CELASTRACEAE
@	*	4630000	00300	PTEROCELASTRUS TRICUSPIDATUS (LAM.) SOND.	CELASTRACEAE
	DU	4641000	00000	CASSINE BUEHANII LOES.	CELASTRACEAE
	**	4641000	00700	CASSINE MARITINUM L.BOL.	CELASTRACEAE
@	#	4641000	00900	CASSINE PERAGUA L.	CELASTRACEAE
	DU	4641000	00000	CASSINE SCHWEINFURTHIANA LOES.	CELASTRACEAE
	KI	4645000	00100	HARTOGIELLA SCHINOIDES (SPRENG.) CODD	CELASTRACEAE
	DU	4662000	00500	SALACIA REHMANNI SCHINZ.	CELASTRACEAE
	DU	4663000	00000	APODOSTIGMA PALLENS SCHINZ.	CELASTRACEAE
	DU	4734000	00000	ALLOPHYLLUS GRISTEMENTOSUS GILG.	SAPINDACEAE
	*	4734000	00750	ALLOPHYLLUS UNDULATA	SAPINDACEAE
	**	4784000	00100	PAPPEA CAPENSIS ECKL.& ZEYH.	SAPINDACEAE
@	KI	4831000	00100	DODONAEA ANGUSTIFOLIA L.F.	SAPINDACEAE
@	**	4854000	00100	MELIANTHUS COMOSUS VAHL.	MELIANTHACEAE
@	*	4854000	00200	MELIANTHUS DREGEANUS SOND.	MELIANTHACEAE
@	*	4856000	00350	IMPATIENS HOCHSTETTERI WARD.	BALSIMNACEAE
	DU	4861000	00000	ZIZYPHUS PUBESCENS OLIV.	RHAMNACEAE
@	**	4874000	00100	SCUTIA MYRTINA (BURM.F.) KURTZ.	RHAMNACEAE
@	**	4875000	00100	RHAMNUS PRINOIDES L'HERIT	RHAMNACEAE
@	#	4886000	00300	PHYLICA AEMULA SCHLTR.VAR.AEMULA	RHAMNACEAE
@	#	4886000	00400	PHYLICA AEMULA SCHLTR.VAR.MULTIBRACTEOLATA PILLANS	RHAMNACEAE
@	#	4886000	01100	PHYLICA AMBIGUA SOND.	RHAMNACEAE
@	JS	4886000	01200	PHYLICA AMOENA	RHAMNACEAE
@	#	4886000	02700	PHYLICA BARNARDII PILLANS	RHAMNACEAE
	DU	4886000	03000	PHYLICA BUXIFOLIA L.	RHAMNACEAE
@	#	4886000	04100	PHYLICA CONSTRICTA PILLANS VAR.CONSTRICTA	RHAMNACEAE
@	#	4886000	04400	PHYLICA CRYPTANDROIDES SOND.	RHAMNACEAE
@	#	4886000	04800	PHYLICA CYLINDRICA WENDL.	RHAMNACEAE
	*	4886000	06400	PHYLICA EXCELSA WENDL.	RHAMNACEAE
@	#	4886000	06800	PHYLICA FRUTICOSA SCHLTR.	RHAMNACEAE
	*	4886000	06900	PHYLICA GALPINII PILLANS	RHAMNACEAE
	*	4886000	07400	PHYLICA GUTHERI PILLANS	RHAMNACEAE
	*	4886000	07900	PHYLICA IMBERBIS BERG. VAR.IMBERBIS	RHAMNACEAE
@	#	4886000	08200	PHYLICA INSIGNIS PILLANS	RHAMNACEAE
@	#	4886000	09400	PHYLICA LEIPOLDTII PILLANS	RHAMNACEAE
@	#	4886000	11600	PHYLICA ODORATA SCHLTR.	RHAMNACEAE
	*	4886000	11700	PHYLICA OLEIFOLIA VENT.	RHAMNACEAE
@	#	4886000	12500	PHYLICA PLUMIGERA PILLANS	RHAMNACEAE
@	#	4886000	13300	PHYLICA PULCHELLA SCHLTR.	RHAMNACEAE
@	#	4886000	14200	PHYLICA RIGIDA ECKL.& ZEYH.	RHAMNACEAE
@	#	4886000	14300	PHYLICA RIGIDIFOLIA SOND.	RHAMNACEAE
@	#	4886000	15600	PHYLICA STIPULARIS L.	RHAMNACEAE
	TH	4886000	16500	PHYLICA THODEI	RHAMNACEAE
@	#	4886000	17500	PHYLICA VILLOSA THUNB.VAR.PEDICELLATA (DC.) SOND.	RHAMNACEAE
@	#	4886000	17600	PHYLICA VILLOSA THUNB.VAR.VILLOSA	RHAMNACEAE
@	*	4905000	00100	HELINUS INTEGRIFOLIUM (LAM.) KUNTZE	RHAMNACEAE
@	**	4917000	99999	RHOICUSSUS SP.	VITACEAE

@	*	4918000	00700	CYPHOSTEMMA CIRRHOSUM (THUNB.) DESC.EX. WILLD.& DRUM	VITACEAE
@	*	4918010	02400	CYPHOSTEMMA QUINATUM (DRYLAND) DESC. EX. WILLD. & DRUM	VITACEAE
	DU	4966000	01600	GREWIA MONTICOLA SOND.	TILIACEAE
	*	4966000	01700	GREWIA OCCIDENTALIS L.	TILIACEAE
	DU	4966000	00000	GREWIA PLAGIOPHYLLA K.SCH.	TILIACEAE
	DU	4966000	00000	GREWIA PRAECOX K.SCHUM.	TILIACEAE
@	**	4966000	01900	GREWIA ROBUSTA BURGII	TILIACEAE
	*	4966000	99999	GREWIA SP.	TILIACEAE
	DU	4983000	00000	ABUTILON LONGICUSPE A.RICH	MALVACEAE
	DU	4983000	01500	ABUTILON MAURITIANUM (JACQ.)	MALVACEAE
@	*	4983000	02100	ABUTILON SONNERIATUM (CAV.) SWEET.	MALVACEAE
@	**	4986010	99999	ANISODONTEA SP.	MALVACEAE
@	*	5007000	00300	PAVONIA COLUMELLA CAV.	MALVACEAE
	DU	5007000	01300	PAVONIA URENS CAV.	MALVACEAE
	DU	5013000	00100	HIBISCUS AETHIOPICUS L.	MALVACEAE
@	JS	5013000	00600	HIBISCUS ARIDUS R.A.DYER	MALVACEAE
@	**	5013000	04300	HIBISCUS PUSILLUS THUNB.	MALVACEAE
	TH	5013000	05300	HIBISCUS TRIONUM	MALVACEAE
@	**	5013010	00100	RADYERA URENS (L.F.) BULLOCK.	MALVACEAE
	DU	5053000	00000	DOMBEYA GOETZENII K.SCHUN.	STERCULIACEAE
	DU	5053000	00000	DOMBEYA UMBRACULIFERA K.SCHUN.	STERCULIACEAE
@	JS	5056000	00100	HERMANNIA ABROTANIODES SCHRAD.	STERCULIACEAE
	*	5056000	03910	HERMANNIA CARD.	STERCULIACEAE
@	**	5056000	04500	HERMANNIA COMASA BURCH.EX.DC.	STERCULIACEAE
@	*	5056000	05100	HERMANNIA CONFUSA SALTER	STERCULIACEAE
@	**	5056000	05700	HERMANNIA CUNEIFOLIA JACQ. VAR CUNEIFOLIA	STERCULIACEAE
@	#	5056000	06700	HERMANNIA DENUDATA L.F.VAR.DENUDATA	STERCULIACEAE
@	**	5056000	07300	HERMANNIA DESERTORUM ECKL.& ZEYH.	STERCULIACEAE
@	**	5056000	09100	HERMANNIA FILIFOLIA L.F.	STERCULIACEAE
@	**	5056000	11900	HERMANNIA GRANDIFLORA AIT.	STERCULIACEAE
@	**	5056000	13700	HERMANNIA HOLOSERICA JACQ.	STERCULIACEAE
@	*	5056000	16700	HERMANNIA LINIFOLIA BURM.F.	STERCULIACEAE
@	#	5056000	20100	HERMANNIA MURICATA ECKL.& ZEYH.	STERCULIACEAE
@	#	5056000	20500	HERMANNIA ODORATA AIT.	STERCULIACEAE
@	#	5056000	24300	HERMANNIA RUDIS N.E.BR.	STERCULIACEAE
@	#	5056000	25500	HERMANNIA SCABRA CAV.	STERCULIACEAE
@	#	5056000	26300	HERMANNIA SISYMBRIFOLIA (TURCZ.) HOCHR.	STERCULIACEAE
@	**	5056000	26700	HERMANNIA SPINOSA E.MEY.EX HARV.	STERCULIACEAE
@	**	5056000	27300	HERMANNIA STIPULACEAE LEHM.EX ECKL..& ZEYH.	STERCULIACEAE
@	#	5056000	29100	HERMANNIA TRIFURCA L.	STERCULIACEAE
@	**	5056000	29900	HERMANNIA VESTATA THUNB.	STERCULIACEAE
	**	5056000	99999	HERMANNIA SP.	STERCULIACEAE
	DU	5083000	00000	STERCULIA APPENDICULATA K.SCHUM.	STERCULIACEAE
	DU	5112000	00600	OCHNA HOLSTII ENGL.	OCHNACEAE
	DU	5112000	00000	OCHNA THOMASIANA ENGL.	OCHNACEAE
@	*	5168000	00400	HYPERICUM LALANDII CHOISY	CLUSIACEAE
	TH	5168000	00400	HYPERICUM LALANDII CHOISY	CLUSIACEAE
	DU	5239000	00000	TAMARIX BOUNOPAEA J.GAY	TAMARIACEAE
	DU	5239000	00000	TAMARIX NILOTICA (EHRENB.) BUNGE	TAMARIACEAE
@	**	5296000	00100	KIGGELARIA AFRICANUM L.	FLACOURTIACEAE
@	*	5304000	00500	SCOLPIA ZEYHERI	FLACOURTIACEAE
	DU	5328000	00100	DORYALIS CAFFRA (HOOK.F.)	FLACOURTIACEAE
	DU	5355000	00400	WORMSKIOLDIA LONGEPEDUNCULATA MAST.	TURNERACEAE
	TH	5397000	00400	BEGONIA DREGEI	BEGONIACEAE
	DU	5417000	00000	OPUNTIA RAFINESQUII ENGLEM.	CACTACEAE
@	*	5428000	00050	OLINIA CYMOSA	OLINIACEAE
@	*	5428000	00400	OLINIA VENTOSA (L.) CUFOD.	OLINIACEAE

	DU	5434000 00000	PEDDIEA VOLKENSII GILG.	THYMELAEACEAE
@	#	5435000 01320	GNIDIA DESERTICOLA GILG.	THYMELAEACEAE
@	#	5435000 02000	GNIDIA GEMINIFLORA E.MEY.EX.MEISN.	THYMELAEACEAE
@	*	5435000 03000	GNIDIA LINEARIFOLIA (WIKSTR.) PETERSON	THYMELAEACEAE
@	*	5435000 03300	GNIDIA MEYERI MEISN.	THYMELAEACEAE
@	*	5435000 03700	GNIDIA NANA (L.F.) WIKSTR.	THYMELAEACEAE
@	#	5435000 04100	GNIDIA OPPOSITIFOLIA L.	THYMELAEACEAE
@	#	5435000 04600	GNIDIA PENICILLATA LICHT.EX.MEISN.	THYMELAEACEAE
@	*	5435000 04700	GNIDIA PHAETRICHYA GILG.	THYMELAEACEAE
@	#	5435000 05500	GNIDIA SCABRA THUNB.	THYMELAEACEAE
	**	5435000 06500	GNIDIA STYPHELOIDES MEISN.	THYMELAEACEAE
@	#	5436000 00600	STRUTHIOLA CILIATA (L.) LAM. SUBSP. INCANA (LODD.) PETERSON	THYMELAEACEAE
@	#	5436000 01800	STRUTHIOLA LEPTANTHA H.BOL.	THYMELAEACEAE
@	#	5436000 01900	STRUTHIOLA LINEARILOBA MEISN.	THYMELAEACEAE
@	#	5459000 99999	CRYPTADENTIA SP.	THYMELAEACEAE
@	#	5460000 01500	LACHNAEA FILIMENTOSA (THUNB.) MEISN. VAR. FILAMENTOSA	THYMELAEACEAE
@	#	5460000 02150	LACHNAEA NAVICULIFOLIA COMPTON	THYMELAEACEAE
@	#	5460000 02600	LACHNAE STRIATA (LAM.)MEISN.	THYMELAEACEAE
@	#	5460000 99999	LACHNAEA SP.	THYMELAEACEAE
@	#	5461000 00810	PASSERINA MONTANA THODAY	THYMELAEACEAE
@	**	5461000 00910	PASSERINA OBTUSIFOLIA THODAY.	THYMELAEACEAE
@	*	5461000 01500	PASSERINA VULGARIS THODAY.	THYMELAEACEAE
	*	5461000 99999	PASSERINA SP.	THYMELAEACEAE
	**	0000000 00000	LASSIOSSIPHON ANTHYLLOIDES	THYMELAEACEAE
	**	0000000 00000	LASIOSSIPHON MAMERIAMUS	THYMELAEACEAE
@	*	5476000 00300	LYTHRIUM HYSSOPIFOLIUM L.	LYTHRACEAE
	DU	5520000 00000	ANOPYXIS EALENSIS (DE WILD.) SPAGUE	RHIZOPHORACEAE
@	*	5529000 00100	CASSIOPOUREA FLANAGANII (SCHINZ.) ALSTON.	RHIZOPHORACEAE
	*	5529000 00400	CASSIPOUREA MOSSAMBIENSIS (V.BREHM.) ALSTON	RHIZOPHORACEAE
	DU	5538000 02100	COMBRETUM MOLLEE R.BR. EX G.DON.	COMBRETACEAE
	DU	5538000 02800	COMBRETUM PSIDIOIDES WELIN.	COMBRETACEAE
	DU	5553000 00000	EUCALYPTUS TERETICORNIS SM.	MYRTACEAE
	DU	5578000 00000	EUGENIA CARYOPHYLLUS	MYRTACEAE
@	#	5588000 00100	METROSIDEROS ANGUSTIFOLIA (L.)J.E.SM.	MYRTACEAE
@	JS	5793000 99999	LUDWIGIA SP.	ONAGRACEAE
@	*	5804000 00900	OENOTHERA ROSEA L'HERIT EX.AIT.	ONAGRACEAE
	DU	5839000 00000	DIZYGOTHECA ELEGANTISSIMA VEITCH.	ARALIACEAE
@	JS	5872000 00400	CUSSONIA PANICULATA ECKL.& ZEYH.	ARALIACEAE
	DU	5872000 00600	CUSSONIA SPICATA THUNB.	ARALIACEAE
		5872000 00000	HEDERA HELIX.	ARALIACEAE
@	#	5894000 00100	CENTELLA AFFINIS (ECKL. & ZEYH.ZO ADAMSON VAR.AFFINIS	APIACEAE
@	*	5894000 02300	CENTELLA GLABRATA L.	APIACEAE
@	#	5894000 04100	CENTELLA SCABRA ADAMSON	APIACEAE
@	#	5894000 99999	CENTELLA SP.	APIACEAE
@	#	5917000 00400	HERMAS GIGANTEA L.F.	APIACEAE
@	#	5926000 00200	ARCTOTUS ECHINATUS L.	APIACEAE
	*	5990000 00400	LICHTENSTEINII INTERRUPTA (THUNB.) E.MEY.	APIACEAE
@	JS	5992000 00100	HETEROMORPHA ARBORESCENS (SPRENG.) CHAM.& SCHLECHTD.	APIACEAE
	DU	5992000 00000	HETEROMORPHA TRIFOLIATA (WENDL.) ECKL.& ZEYH.	APIACEAE
	DU	6004000 00000	APIUM FILIFORME HOOK.F.	APIACEAE
	DU	6006000 00000	PETROSELINUM CRISPUM MILL.	APIACEAE
@	FH	6038010 00100	BERULA ERECTA (HUDSON) CAV.	APIACEAE
@	*	6078000 00100	ANNESORRHIZA ALTISCARPA SCHLTD.	APIACEAE
@	KI	6078000 00400	ANNESORRHIZA FILICAULIS ECKL.& ZEYH.	APIACEAE
@	**	6116000 01000	PEUCADANUM FERULACEUM THUNB.	APIACEAE
	DU	6143000 00000	TRACHYSPERMUM DIDYMUM (SOMB.) DRUDE	APIACEAE
@	#	6237000 00400	ERICA ACUTA ANDR.	ERICACEAE

	TH	6237000	01700	ERICA ALGIDA	ERICACEAE
@	*	6237000	01800	ERICA ALOPECURUS HARV.	ERICACEAE
@	#	6237000	03500	ERICA ARTICULARIS L.VAR.ARTICULARIS	ERICACEAE
@	#	6237000	05500	ERICA BERGIANA L.	ERICACEAE
@	#	6237000	07900	ERICA BRUNIADES L.	ERICACEAE
@	*	6237000	08100	ERICA CAFFRA L.	ERICACEAE
@	**	6237000	08200	ERICA CAFFRORUM H.BOL. VAR CAFFRORUM	ERICACEAE
@	#	6237000	08500	ERICA CALYCINA L.VAR.CALYCINA	ERICACEAE
@	#	6237000	08800	ERICA CALYCINA L.VAR.PERIPLOCIFLORA (SALISB.) H.BOL.	ERICACEAE
@	#	6237000	10300	ERICA CERNUA C.V.MONTIN	ERICACEAE
	DU	6237000	13000	ERICA CHAMISSONIS KLOTZCH.	ERICACEAE
@	#	6237000	13100	ERICA CONSOBRINA GUTH.& BOL.	ERICACEAE
@	#	6237000	13500	ERICA COPIOSA WENDL. VAR CAPENSIS	ERICACEAE
@	#	6237000	14000	ERICA CORIFOLIA L.	ERICACEAE
@	#	6237000	14780	ERICA CRISTIFLORA SALISB. VAR. BLANDA (SALISB.) H.BOL.	ERICACEAE
@	#	6237000	15730	ERICA CURVIFLORA L.VAR.CURVIFLORA	ERICACEAE
@	#	6237000	16800	ERICA DAPHNIFLORA SALISB.VAR.DAPHNIFLORA	ERICACEAE
@	#	6237000	21700	ERICA EUGENEA DULRER	ERICACEAE
@	#	6237000	29600	ERICA HAEMATOSIPHON GUTH.& BOL.	ERICACEAE
@	#	6237000	31200	ERICA HIRTIFLORA CURTIS	ERICACEAE
@	#	6237000	31700	ERICA HUMIFUSA HIBBERT EX.SALISB.	ERICACEAE
@	*	6237000	32300	ERICA INFLATA THUNB.	ERICACEAE
@	#	6237000	34000	ERICA JUNONIA H.BOL.VAR.JUNONIA	ERICACEAE
@	*	6237000	36000	ERICA LATERALIS WILLD.	ERICACEAE
@	*	6237000	37600	ERICA LEUCODESMA BENTH.	ERICACEAE
@	**	6237000	38570	ERICA LONGIFOLIA AIT VAR. LONGIFOLIA	ERICACEAE
@	#	6237000	39300	ERICA LUCIDA SALISB. VAR.LUCIDA	ERICACEAE
	DU	6237000	39400	ERICA LUTEA BERG.	ERICACEAE
@	#	6237000	40300	ERICA MADERI GUTH.& BOL.	ERICACEAE
@	**	6237000	45000	ERICA MAESTRI H.BOL.	ERICACEAE
@	#	6237000	42900	ERICA MONSONIANA L.F.	ERICACEAE
@	#	6237000	44900	ERICA NUBIGENA H.BOL.VAR.ORESIGENA	ERICACEAE
@	*	6237000	40400	ERICA NUDIFLORA L.	ERICACEAE
@	#	6237000	50600	ERICA PHILIPPIOIDES COMPTON	ERICACEAE
@	#	6237000	51500	ERICA PLACENTIFLORA SALISB.	ERICACEAE
@	#	6237000	56700	ERICA RUBIGINOSA DULFER VAR. RUBIGINOSA	ERICACEAE
@	#	6237000	58100	ERICA SENILIS KLOTZSCH EX.BENTH.	ERICACEAE
@	**	6237000	61600	ERICA SUBULATA WENDL.	ERICACEAE
@	#	6237000	63500	ERICA THUNBERGII C.V.MONTIN.	ERICACEAE
@	#	6237000	65100	ERICA TUMIDA KER-GAWL.VAR.MINOR H.BOL.	ERICACEAE
@	#	6237000	65200	ERICA TUMIDA KER-GAWL.VAR. TUMIDA	ERICACEAE
@	#	6237000	66700	ERICA VANNEURCKII MUELL.ARG.	ERICACEAE
@	#	6237000	67100	ERICA VERECUNDA SALISB.	ERICACEAE
@	#	6237000	68650	ERICA WOODII H.BOL.	ERICACEAE
@	#	6237000	99999	ERICA SP.	ERICACEAE
	DU	6240000	00000	PHILIPPIA KENIENSIS S.MOORE.	ERICACEAE
@	#	6242000	00800	BLAERIA ERICOIDES L.	ERICACEAE
@	#	6243000	00600	EREMIA RECURVATA KLOTZCH.	ERICACEAE
@	#	6243000	00700	EREMIA TOTTA D.DON.	ERICACEAE
@	#	6243020	00400	GRISEBACHIA CILIARIS (L.F.) KLOTZCH. SUBSP. CILIARIS	ERICACEAE
@	#	6243020	01520	GRISEBACHIA PARVIFLORA (KLOTZCH) DRUCE. SUBSP. PARVIFLORA	ERICACEAE
@	#	6244000	01500	SIMOCHEILUS KLOTZCHIANUS BENTH. VAR. KLOTZCHIANUS	ERICACEAE
@	#	6244000	00300	THORACOSPERMA GALPINII N.E.BR.	ERICACEAE
@	#	6245010	00100	ANISERICA GRACILIS (BARTL.) N.E.BR. VAR. GRACILIS	ERICACEAE
	DU	6246000	01600	SCYPHOGYNE RIGIDULA N.W.BR.	ERICACEAE
@	**	6246020	00300	SCYPHOGYNE BURCHELLI N.E.BR.	ERICACEAE
@	#	6246020	01200	SCYPHOGYNE MUSCOSA (AIT.)STEUD.	ERICACEAE

@	#	6313000	00100	MYRSINE AFRICANA L.	MYRSINACEAE
@	*	6314000	00100	RAPANEAE MELANOPHLOEOS (L.) MEZ.	MYRSINACEAE
@	*	6314000	00200	RAPANEAE GILLIANA (SOND.) MEZ.	MYRSINACEAE
	DU	6315000	00000	PRIMULA MISTASSINICA MICHX.	PRIMULACEAE
	*	6338000	99999	ANGULUS SP.	PRIMULACEAE
@	#	6351010	01300	LIMONIUM LONGIFOLIUM (THUNB.) R.A.DYER	PLUMBAGINACEAE
@	#	6351010	01700	LIMONIUM SCABRUM (THUNB.)KUNTZE VAR. AVENACEUM (C.H.WR.) R.A.DYER	PLUMBAGINACEAE
	DU	6345000	00100	DYEROPHYTUM AFRICANUM (LAM.) O.KUNTZE	PLUMBAGINACEAE
@	#	6404000	00100	EUCLEA ACUTIFOLIA E.MEY.EX.A.DC.	EBENACEAE
@	**	6404000	00400	EUCLEA CRISPA (THUNB.) GUERKE	EBENACEAE
	DU	6404000	00600	EUCLEA DIVINORUM HIERN.	EBENACEAE
@	#	6404000	01500	EUCLEA TOMENTOSA E.MEY.EX.A.DC.	EBENACEAE
@	#	6404000	01510	EUCLEA TOMENTOSA X.NATALENSIS	EBENACEAE
@	#	6406000	00200	DIOSPYROS AUSTRO AFRICANA DE WINTER VAR.RUGOSA (E.MEY.EX.A.DC.) DE WINTER	EBENACEAE
@	**	6406000	01400	DIOSPYROS LYCIOIDES DESF.	EBENACEAE
	DU	6419000	00000	LINOCIERA AFRICANA GILG.	OLEACEAE
	DU	6419000	00000	FRAXINUS PENNSYLVANICA MARSH.	OLEACEAE
@	*	6434000	00200	OLEA CAPENSIS L.	OLEACEAE
@	*	6434000	00500	OLEA EXASPERATA JACQ.	OLEACEAE
	DU	6434000	00000	OLEA LANCEA LAM.	OLEACEAE
	DU	6440000	00400	JASMINUM FLUMINENSE VELL.	OLEACEAE
@	*	6469000	00100	NUXIA CONGESTA R.BR.	LOGANIACEAE
@	*	6469000	00200	NUXIA FLORIBUNDA BENTH.	LOGANIACEAE
	DU	6470000	00200	GOMPHOSTIGMA VIRGATUM (L.F.) BAILL.	LOGANIACEAE
@	JS	6473000	00400	BUDDLEJA GLOMERATA WENDL. F.	LOGANIACEAE
@	**	6473000	00700	BUDDLEJA SALVIFLORA (L.) LAM.	LOGANIACEAE
@	#	6481000	00400	SEBAEA AUREA (L.F.) ROEM.& SCHULT.	GENTIACEAE
@	*	6481000	01900	SEBAEA HYMENOSEPALA GILG.	GENTIACEAE
	TH	6481000	03000	SEBAEA NATALENSIS	GENTIACEAE
@	*	6481000	03800	SEBAEA REHMANNII SCHINZ.	GENTIACEAE
@	*	6481000	99999	SEBAEA SP.	GENTIACEAE
@	#	6503000	00100	CHIRONIA ARENARIA E.MEY.	GENTIACEAE
@	#	6503000	00200	CHIRONIA BACCIFERA L.	GENTIACEAE
	TH	6503000	00500	CHIRONIA KREBSII	GENTIACEAE
	DU	6559000	00350	CARISSA GRANDIFLORA (ECKL.) DC.	APOCYNACEAE
@	**	6559000	00400	CARRISSA HAEMATOCARPA (ECKL.) A.DC.	APOCYNACEAE
	DU	6559000	00600	CARISSA TETRAMERA (SAD.) STAPF.	APOCYNACEAE
	**	6681000	00500	PACHYPODIUM SUCCULENTUM (L.F.) SWEET	APOCYNACEAE
	DU	6752000	00000	CRYPTOSTEGIA GRANDIFLORA R.BR.	ASCLEPIADACEAE
	DU	6752000	00000	GLOSSOSTELMA CARSONII (N.E.BR.)	ASCLEPIADACEAE
@	#	6752000	01100	MICROLOMA SAGITTATUM R.BR.	ASCLEPIADACEAE
	*	6777000	00700	MALOBIUM INVOLUCRUM DECNE.	ASCLEPIADACEAE
@	#	6791000	01000	ASCLEPIAS CANCELLATA BURM.F.	ASCLEPIADACEAE
@	**	6791000	05350	ASCLEPIAS ROTUNDIFOLIA	ASCLEPIADACEAE
	DU	6860000	00000	SECOMONE PARVIFOLIA (OLIV.)	ASCLEPIADACEAE
@	#	6878000	00304	HOODIA BAINII T.DYER	ASCLEPIADACEAE
@	**	6881000	00600	PIARANTHUS FOETIDUS NE.B.R.	ASCLEPIADACEAE
@		6881000	00700	PIARANTHUS SUCCULENTUM	ASCLEPIADACEAE
@	#	6885000	01350	STAPELIA CEDRIMONTANA FRANDSEN	ASCLEPIADACEAE
@	**	6885000	01700	TRIDENTIA VIRESCENS (N.E.BR.) LEACH.	ASCLEPIADACEAE
@	#	6968000	01300	CUSCUTA NITIDA E.MEY.EX.CHOISY	CONVOLVULACEAE
	DU	7003000	00000	IPOMOEA OCHRACEAE (LINDL.) G.DON.	CONVOLVULACEAE
@	**	7056000	00100	TRICHODESMA AFRICANUM (L.) LEHM.	BORAGINACEAE
@	#	7117000	00900	LOBOSTEMON ECHIOIDES LEHM.	BORAGINACEAE
@	#	7117000	00900	LOBOSTEMON GLAUCOPHYLLUS (JACQ.) BUEK.	BORAGINACEAE

@	#	7117000	01800	LOBOSTEMON LAEVIGATUS (L.) BUEK.	BORAGINACEAE
@	#	7117000	03000	LOBOSTEMON TRICHOTOMUS (THUNB.) DC.	BORAGINACEAE
@	JS	7118000	00300	EICHIUM VULGARE L.	BORAGINACEAE
	DU	7144000	00000	LANTANA RHODESIENSIS MOLDENKE.	VERBENACEAE
@	*	7144000	00600	LANTANA RUGOSA THUNB.	VERBENACEAE
	DU	7144000	00000	LANTANA VIBURNOIDES (FORSK.) VAHL.	VERBENACEAE
	**	7153000	00500	PRIVA LEPTOS	VERBENACEAE
	DU	7191000	00000	CLERODENDRON DISCOLOR (KLOTZSCH.) VATKE.	VERBENACEAE
	DU	7210000	00000	LAVANDULA MULTIFIDA LINN.	LABIATAE
	*	7211000	00100	AJUGA OPHYDROIDIS BURCH.	LABIATAE
@	*	7264000	00400	LEONOTIS DYASOPHYLLA BENTH.	LABIATAE
	TH	7264000	01100	LEONOTIS LEONURUS	LABIATAE
@	#	7281000	00100	STACHYS AETHIOPICA L.	LABIATAE
	TH	7281000	00100	STACHYS AETHIOPICA L.	LABIATAE
@	#	7281000	00900	STACHYS CUNEATA BANKS EX. BENTH	LABIATAE
@	*	7281000	01500	STACHYS FLEXUOSA SKAN.	LABIATAE
@	**	7281000	01800	STACHYS GRANDIFLORA E.MEY.EX BENTH.	LABIATAE
@	#	7281000	03300	STACHYS RUGOSA AIT.	LABIATAE
@	**	7281000	03800	STACHYS SPATHULATA BURCH.EX.BENTH.	LABIATAE
@	#	7290000	01000	SALVIA DISERMAS L.	LABIATAE
@	#	7290000	00200	SALVIA ALBUCAULIS BENTH.	LABIATAE
@	#	7290000	00300	SALVIA AFRICANA-LUTEA L.	LABIATAE
@	#	7290000	00700	SALVIA CHAMELAEAGNEA BERG.	LABIATAE
	**	7290000	02900	SALVIA VERBENACEAE L.	LABIATAE
@	**	7328000	00100	MENTHA AQUATICA L.	LABIATAE
@	#	7328000	00100	MENTHA LONGIFOLIA (L.) HUDS.SUBSP.CAPENSIS (THUNB.)BRIQ.	LABIATAE
@	*	7350000	00600	PLECTRANTHUS CILIATUS E.MEY.EX.BENTH.	LABIATAE
@	*	7350000	01000	PLECTRANTHUS ECKLONII BENTH.	LABIATAE
@	*	7350000	01400	PLECTRANTHUS GRALLATUS BRIQ.	LABIATAE
@	*	7350000	03200	PLECTRANTHUS STRIGOSUS BENTH.	LABIATAE
	*	7350030	00100	RABDOSIA CALYCINA (BENTH.) CODD.	LABIATAE
	TH	7366010	00400	BECIUM OBOVATUM	LABIATAE
	DU	7366010	99999	BECIUM SP.	LABIATAE
@	FH	7379000	00400	LYCIUM CINEREUM THUNB. (SENS.LAT.)	SOLANACEAE
	DU	7379000	00000	LYCIUM EUROPAEUM L.	SOLANACEAE
@	*	7379000	00700	LYCIUM FEROCISSIMUM MIERS	SOLANACEAE
@	**	7379000	00900	LYCIUM OXYCARPUM DUN.	SOLANACEAE
	*	7379000	01200	LYCIUM SCHIZOCALYX C.H.WR.	SOLANACEAE
	DU	7401000	00000	PHYSOLIS HETEROPHYLLA NEES	SOLANACEAE
@	**	7407000	01300	SOLANUM COCCINEUM JACQ.	SOLANACEAE
	DU	7407000	03200	SOLANUM INCANUM L.	SOLANACEAE
@	*	7407000	05800	SOLANUM GIGANTEUM JACQ.	SOLANACEAE
	**	7407000	05900	SOLANUM RUBELLORUM JACQ.	SOLANACEAE
	**	7407000	99999	SOLANUM SP.	SOLANACEAE
	*	7434000	00200	NICOTINA GLAUCA	SOLANACEAE
	DU	7435000	00000	DISCOPODIUM EREMANTHUM CHIOV.	SOLANACEAE
@	*	7467000	01250	APTOSIUM PROCUMBENS (LEHM.) STEUD.	SCROPHULARIACEAE
@	*	7467000	01400	APTOSIUM SPINESCENS (THUNB.) WEBER	SCROPHULARIACEAE
	DU	7471000	01000	DIASCIA ENGLERI DIELS.	SCROPHULARIACEAE
@	#	7471000	02000	DIASCIA LONGICORNIS (THUNB.) DRUCE	SCROPHULARIACEAE
@	*	7471000	03100	DIASCIA RIGESCENS E.MEY.EX.BENTH.	SCROPHULARIACEAE
@	#	7472000	00400	HEMIMERIS SABULOSA L.F.	SCROPHULARIACEAE
	DU	7472000	00400	HEMIMERIS SABULOSA L.F.	SCROPHULARIACEAE
@	#	7472000	00700	NEMISIA BARBATA BENTH.	SCROPHULARIACEAE
@	JS	7476000	01150	NEMISIA CAPENSIS L.	SCROPHULARIACEAE
@	#	7476000	01300	NEMISIA CHEIRANTHUS E.MEY.EX.BENTH	SCROPHULARIACEAE
@	#	7476000	02500	NEMISIA FRUTICANS (THUNB.) BENTH.	SCROPHULARIACEAE

@	#	7476000	03700	NEMISIA LIGULATA E.MEY.EX.BENTH.	SCROPHULARIACEAE
@	#	7476000	04600	NEMISIA PARVIFLORA BENTH.	SCROPHULARIACEAE
@	JS	7476000	99999	NEMISIA SP.	SCROPHULARIACEAE
	DU	7477000	00100	DICLIS PETIOLARIS BENTH.	SCROPHULARIACEAE
@	#	7493000	00100	HALLERIA ELLIPTICA L.	SCROPHULARIACEAE
@	TH	7493000	00200	HALLERIA LUCIDA	SCROPHULARIACEAE
@	#	7494010	00100	OFTIA AFRICANA (L.) BOCR.	SCROPHULARIACEAE
@	#	7498000	00100	IXIANTHES RETZIOIDES BENTH.	SCROPHULARIACEAE
@	TH	7500000	00300	BOWKERIA VERTICILLATA	SCROPHULARIACEAE
@	#	7517000	02300	MANULEA LAXA SCHLTR.	SCROPHULARIACEAE
@	#	7517000	03100	MANULEA RIGIDA BENTH.	SCROPHULARIACEAE
@	#	7519000	00400	SUTERA AETHIOPICA (L.) KUNTZE	SCROPHULARIACEAE
	DU	7565000	00000	PARASTRIGA ALECTROIDIS MILDB.	SCROPHULARIACEAE
	DU	7565000	00000	PEDICULARIS LANATA CHAM. & SCHLECHT.	SCROPHULARIACEAE
	DU	7565000	00000	RADAMAEA SP	SCROPHULARIACEAE
	DU	7565000	00000	SCROPHULARIA CANINA L.	SCROPHULARIACEAE
	DU	7565000	00000	SCROPHULARIA SP.	SCROPHULARIACEAE
@	**	7590000	01700	SUTERA AURANTIACA (BURCH.) HIERN.	SCROPHULARIACEAE
@	*	7519000	02500	SUTERA CAERULEA (L.F.) HIERN.	SCROPHULARIACEAE
@	**	7519000	02700	SUTERA CAMPANULATA (BENTH.) KUNTZE	SCROPHULARIACEAE
@	#	7519000	04400	SUTERA FOETIDA (ANDR.) ROTH	SCROPHULARIACEAE
@	**	7519000	05200	SUTERA HALIMIFOLIA (BENTH.) KUNZE	SCROPHULARIACEAE
@	**	7519000	08000	SUTERA LINNIFOLIA KUNTZE.	SCROPHULARIACEAE
@	**	7519000	08700	SUTERA PAUCIFLORA (BENTH.) KUNTZE.	SCROPHULARIACEAE
@	*	7519000	09100	SUTERA PINNATIFIDA KUNTZE	SCROPHULARIACEAE
@	*	7519000	09300	SUTERA POLELENSIS HIERN.	SCROPHULARIACEAE
@	#	7519000	11600	SUTERA TRISTIS (L.F.) HIERN.	SCROPHULARIACEAE
	**	7519000	99999	SUTERA SP.	SCROPHULARIACEAE
@	#	7521000	00085	PHYLLOPODIUM CUNEIFOLIUM HIERN	SCROPHULARIACEAE
@	#	7522000	00300	POLYCARENA AUREA BENTH.	SCROPHULARIACEAE
@	#	7522000	00600	POLYCARENA CAPENSIS BENTH	SCROPHULARIACEAE
@	#	7522000	02000	POLYCARENA LEIPOLDTII HIERN.	SCROPHULARIACEAE
@	#	7522000	02800	POLYCARENA RARIFLORA BENTH.	SCROPHULARIACEAE
	*	7523000	00500	ZALUXIANSKYA CAPENSIS WALP.	SCROPHULARIACEAE
	**	7523000	00500	ZALUZIANSKYA CAPENSIS WALP.	SCROPHULARIACEAE
	#	7523000	02600	ZALUZIANSKYA PEDUNCULARIS WALP.	SCROPHULARIACEAE
@	#	7523000	03000	ZALUZIANSKYA VIOLACEAE SCHLTR.	SCROPHULARIACEAE
@	FH	7558000	00100	LIMOSELLA AFRICANA GLUECK	SCROPHULARIACEAE
	**	7558000	00300	LIMOSELLA CAPENSIS THUNB.	SCROPHULARIACEAE
@	**	7566000	00600	HEBENSTREITIA DENTATA L.	SELAGINACEAE
@	#	7566000	01500	HEBENSTREITIA LANCEOLATA (E.MEY.) ROLFE	SELAGINACEAE
	**	7556000	01900	HEBENSTREITIA PARVIFLORA E.MEY.	SELAGINACEAE
@	#	7566000	02350	HEBENSTREITIA ROBUSTA E.MEY.	SELAGINACEAE
@	FH	7568000	00300	SELAGO ALBIDA CHOISY	SELAGINACEAE
@	JS	7568000	01700	SELAGO CORYMBOSA L.	SELAGINACEAE
@	JS	7568000	02600	SELAGO FORBESII ROLFE	SELAGINACEAE
@	#	7568000	03200	SELAGO GLUTINOSA E.MEY.	SELAGINACEAE
@	#	7568000	03600	SELAGO HETEROPHYLLA E.MEY.	SELAGINACEAE
@	#	7568000	03700	SELAGO HIRTA L.F.	SELAGINACEAE
@	#	7568000	08400	SELAGO SERRATA BERG.	SELAGINACEAE
@	*	7568000	08600	SELAGO SPECIOSA ROLFE	SELAGINACEAE
@	#	7568000	08800	SELAGO SPURIA L.	SELAGINACEAE
@	#	7568000	09400	SELAGO TEPHRODES E.MEY.	SELAGINACEAE
@	#	7568000	10700	SELAGO ZEYHERI ROLFE.	SELAGINACEAE
@	*	7568010	01000	WALAFRIDA DENSIFLORA (ROLFE) ROLFE.	SELAGINACEAE
@	*	7568010	01700	WALAFRIDA MICRANTHA (CHOISY) ROLFE.	SELAGINACEAE
@	JS	7568010	02200	WALAFRIDA PANICULATA (THUNB.) ROLFE.	SELAGINACEAE

@	FH	7568010	02800	WALAFRIDA SAXITALIS (E.MEY.) ROLFE	SELAGINACEAE
	**	7568010	99999	WALAFRIDA SP.	SELAGINACEAE
@	#	7569000	00100	MICRODON CAPITATUS (BERG.) LEVYNS.	SELAGINACEAE
@	#	7571000	00100	AGATHELPIS DUBIA (L.) HUTCH.	SELAGINACEAE
@		7271000	00200	AGATHELPIS NITIDA E.MEY.	SELAGINACEAE
@	*	7597000	00200	MELASMA SCABRUM BERG.	SELAGINACEAE
	DU	7597000	00000	MELASMA SESSILIFOLIUM HIERN.	SELAGINACEAE
	TH	7616000	00100	SOPUBIA CANA	SCROPHULARIACEAE
	*	7622000	00200	BUCHNERA DURA BENTH.	SCROPHULARIACEAE
	*	7622000	00300	BUCHNERA GLABRATA BENTH.	SCROPHULARIACEAE
	*	7622000	01000	BUCHNERA TRIXAGO L.	SCROPHULARIACEAE
	TH	7623000	00300	CYNCIUM RACEMOSUM	SCROPHULARIACEAE
	DU	7624000	00000	CHAENOSTOMA AFFINE BERNH.	SCROPHULARIACEAE
	TH	7627000	01100	HARVEYA LAXIFLORA	SCROPHULARIACEAE
@	*	7627000	99999	HARVEYA SP.	SELAGINACEAE
	DU	7662000	00000	CATALPA BIGNONIOIDES GRAY.	BIGNONIACEAE
@	*	7713000	00100	TECOMARIA CAPENSIS (THUNB.) SPACH.	BIGNONIACEAE
	DU	7713000	00000	TECOMARIA STANS (L.) H.K.	BIGNONIACEAE
@	**	7722000	00200	RHIGOZUM OBOVATUM BURCH.	BIGNONIACEAE
@	**	7722000	00300	RHIGOZUM TRICHOTOMUM BURCH.	BIGNONIACEAE
	DU	7744000	00100	MARKHAMIA ACUMINATA K.SCHUM.	BIGNONIACEAE
	*	7744000	00150	MARKHAMIA HILDEBRANDTII	BIGNONIACEAE
	DU	7744000	00000	MARKHAMIA ZANZIBARICA K.SCHUM.	BIGNONIACEAE
@	*	7744000	00000	SPATHODEAE	BIGNONIACEAE
	DU	7771000	00100	HARPAGOPHYTUM PROCUMBENS (BURCH.) DC.	PEDALIACEAE
	TH	7823000	00200	STREPTOCARPUS BOLUSII	GESNERIACEAE
	TH	7823000	01100	STREPTOCARPUS DAVIESII	GESNERIACEAE
	TH	7823000	01800	STREPTOCARPUS GARDENII	GESNERIACEAE
@	*	7823000	02900	STREPTOCARPUS MONTIGENA BRITTEN	GESNERIACEAE
@	#	7901000	00300	URTRICULARIA CAPENSIS SPRENG.	LENTIBULARIACEAE
	DU	7901000	00000	URTRICULARIA MICROCALYX P.TAYLOR.	LENTIBULARIACEAE
	DU	7901000	01300	URTRICULARIA SANDERSONII	LENTIBULARIACEAE
	DU	7906000	00000	ACANTHUS ARBOREA	ACANTHACEAE
	**	7973000	01700	BARLERIA IRRITANS NEES.	ACANTHACEAE
@	#	7973000	04000	BARLERIA STIMULANS E.MEY. EX NEES.	ACANTHACEAE
@	*	7973000	99999	BARLERIA SP.	ACANTHACEAE
@	*	7980000	03500	BLEPHARIS CAPENSIS (L.F.) PERS	ACANTHACEAE
@	**	7980000	03600	BLEPHARIS NITRATA C.B.CL.	ACANTHACEAE
@	**	8007000	00150	ASYSTASIA COROMANDELIANA	ACANTHACEAE
@	*	8007000	00500	ASYSTASIA STENSIPHON C.B.CL.	ACANTHACEAE
@	*	8032000	00500	HYPOESTIS VERTICILLARIS (L.F.) R.BR.EX. CB. CL.	ACANTHACEAE
@	*	8094000	02900	JUSTICA PROTRACTA (NEES)T.ANDERS	ACANTHACEAE
@	**	8094010	01600	MONECHMA INCANUM (NEES) C.B.CL.	ACANTHACEAE
@	*	8094010	99999	MONECHMA SP.	ACANTHACEAE
@	*	8116000	00400	PLANTAGO LANCEOLATA L.	PLANTAGINACEAE
	DU	8116000	00000	PLANTANUS OCCIDENTALIS L.	PLANTAGINACEAE
	TH	8348000	00300	PENTANISIA PRUNELLOIDES	RUBIACEAE
	DU	8351020	00000	PYGMAEOTHAMUS ZEYHERI (SOND.)	RUBIACEAE
	DU	8351030	00000	TAPIPHYLLUM SCHUMANNIANUM ROBYNS.	RUBIACEAE
@	*	8352000	00100	CANTHIUM CILIATUM (KLOTZCH) KUNTZE.	RUBIACEAE
	DU	8352000	01100	CANTHIUM SETIFLORUM HIERN.	RUBIACEAE
@	*	8136060	00100	KOHAUTIA AMATYMBICA ECKL.& ZEYH.	RUBIACEAE
	**	8281000	00100	BURCHELLIA BUBALINA (L.F.) SIMS	RUBIACEAE
	DU	8383000	00000	PAVETTA ABYSSINICA FRES.	RUBIACEAE
@	*	8383000	01100	PAVETTA CAPENSIS (HOUTT.) BREM.	RUBIACEAE
	DU	8399000	00000	PSYCHOTRIA KIRKII HIERN.	RUBIACEAE
	DU	8399000	00000	PSYCHOTRIA PUNCTATA VATKE.	RUBIACEAE

	*	8438000	00900	ANTHOSPERMUM HERDACEUM L.F.	RUBIACEAE
@	#	8438000	01600	ANTHOSPERMUM PROSTRATUM SOND.	RUBIACEAE
@	#	8438000	03000	ANTHOSPERMUM TRICOSTATUM	RUBIACEAE
@	#	8438000	99999	ANTHOSPERMUM SP.	RUBIACEAE
@	#	8486000	00300	GALIUM CAPENSE THUNB. SUBSP.CAPENSE	RUBIACEAE
@	#	8496000	00370	GALIUM CAPENSE THUNB.SUBSP.NAMAQUENSE (ECKL.& ZEYH.)PUFF.	RUBIACEAE
@	*	8546000	00600	SCABIOSA COLUMBARIA L.	DIPSACACEAE
	TH	8546000	00600	SCABIOSA COLUMBARIA L.	DIPSACACEAE
	TH	8546000	00700	SCABIOSA DRAKENSBERGENSIS	DIPSACACEAE
@	*	8564000	00300	ZEHNERIA SCABRA (L.F.) SOND.	CUCURBITACEAE
	DU	8612000	99999	PEPONIUM SP	CUCURBITACEAE
	DU	8662000	01200	ROELLA GLOMERATA A.DC.	CAMPANULACEAE
@	#	8663000	00300	PRISMATOCARPUS BREVILOBUS A.DC.	CAMPANULACEAE
@	#	8663000	00400	PRISMATOCARPUS CAMPANULOIDES	CAMPANULACEAE
@	#	8663000	01100	PRISMATOCARPUS DECURRENS ADAMSON.	CAMPANULACEAE
	DU	8663000	01200	PRISMATOCARPUS DIFFUSUS DC.	CAMPANULACEAE
@	#	8663000	01400	PRISMATOCARPUS FRUTICOSUS L'HERIT.	CAMPANULACEAE
@	#	8663000	02200	PRISMATOCARPUS PAUCIFLORUS ADAMSON.	CAMPANULACEAE
@	#	8668000	00500	WAHLENBERGIA ANNULARIS A.DC.	CAMPANULACEAE
@	**	8668000	01700	WAHLENBERGIA CAPILLACEAE (THUNB.) A.DC.	CAMPANULACEAE
@	#	8668000	03800	WAHLENBERGIA COSTATA A.DC.	CAMPANULACEAE
@	#	8668000	03800	WAHLENBERGIA ECKLONII BUEK.	CAMPANULACEAE
	**	8668000	13100	WAHLENBERGIA UNDULATA (THUNB.) A.DC.	CAMPANULACEAE
	TH	8668000	13100	WAHLENBERGIA UNDULATA (THUNB.) A.DC.	CAMPANULACEAE
@	**	8668000	99999	WAHLENBERGIA SP.	CAMPANULACEAE
	**	8670000	03300	LIGHTFOOTIA NODOSA BUEK.	LOBELIACEAE
@	**	8681000	01300	CYPHIA DIGITATA (THUNB.) WILLD.	LOBELIACEAE
@	**	8681000	02500	CYPHIA INCISA (L.) WILLD. VAR. INCISA	LOBELIACEAE
	DU	8694000	00000	LOBELIA ABERICA R.E. & TH.FRIES.	LOBELIACEAE
@	*	8694000	00500	LOBELIA ANCEPS L.F.	LOBELIACEAE
	TH	8694000	02100	LOBELIA DECIPIENS	LOBELIACEAE
@	*	8694000	02800	LOBELIA ERINUS L.	LOBELIACEAE
	DU	8694000	03000	LOBELIA ELONONENSIS R.E. FRIES.	LOBELIACEAE
	TH	8694000	03600	LOBELIA FILIFORMIS	LOBELIACEAE
	DU	8694000	00000	LOBELIA GIBBEROA HEMSL.	LOBELIACEAE
@	#	8694000	08200	LOBELIA SPARTIOIDES (PRESL.)D.DIETR.	LOBELIACEAE
@	#	8694000	99999	LOBELIA SP.	LOBELIACEAE
	*	8695000	01200	MONOPSIS SCABRA (THUNB.) URB.	LOBELIACEAE
@	#	8694000	01500	MONOPSIS SIMPLEX (L.) E.WIMM.VAR.SIMPLEX.	LOBELIACEAE
@	#	8699000	00100	LAURENTIA ARABIDEA (PRESL.) A.DC.	LOBELIACEAE
@	*	8699000	00700	LAURENTIA PYGMAEA SOND.	LOBELIACEAE
	DU	8716000	00000	SCAEVOLA TACCADA (GAERTEN.) ROXB.	GOODENIACEAE
	DU	8729000	00000	AMPHIDOXA FILAGINEA D.HIERN.	ASTERACEAE
	DU	8751000	00000	VERNONIA AMPLA O.HOFFM.	ASTERACEAE
@	*	8751000	00600	VERNONIA ANISOCHAETOIDES SOND.	ASTERACEAE
@	**	8751000	00700	VERNONIA CAPENSIS (HOUTT.) DRUCE	ASTERACEAE
@	**	8751000	01350	VERNONIA DECURRENS	ASTERACEAE
@	*	8751000	02450	VERNONIA NEOCORYMBOSA HILLIARD	ASTERACEAE
@	#	8764000	00100	CORYMBIUM AFRICANUM L.	ASTERACEAE
	DU	8764000	00200	CORYMBIUM CYMOSUM E.MEY.	ASTERACEAE
@	FH	8764000	00350	CORYMBIUM LAXUM COMPTON.	ASTERACEAE
@	*	8766000	00700	CORYMBIUM VILLOSUM LESS.	ASTERACEAE
@	#	8862000	00600	PTERONIA ASPALATHA DC.	ASTERACEAE
@	#	8862000	01100	PTERONIA CAMPORATA L.VAR.ARMATA HARV.	ASTERACEAE
@	#	8862000	01300	PTERONIA CAMPORATA L.VAR.LAEVIGATA HARV.	ASTERACEAE
@	#	8862000	01900	PTERONIA DIVARICATA (BERG.) LESS.	ASTERACEAE
@	**	8862000	03100	PTERONIA GLOMERATA L.F.	ASTERACEAE

@	**	8862000 03500	PTERONIA INCANA (BURM.) DC.	ASTERACEAE
@	**	8862000 04200	PTERONIA MEMBRANACEAE L.F.	ASTERACEAE
@	#	8862000 04900	PTERONIA PALLENS L.F.	ASTERACEAE
@	#	8862000 99999	PTERONIA SP.	ASTERACEAE
@	KI	8883000 00500	MAIREA ECKLONIS (DC.) SOND.	ASTERACEAE
@	KI	8883000 00900	MAIREA MICROCEPHALUS (LESS.) DC.	ASTERACEAE
@	KI	8883000 01100	MAIREA PEREZIOIDES NEES.	ASTERACEAE
@	*	8900000 00300	ASTER BAKERIANUS (L.F.) O.HOFFM.	ASTERACEAE
	TH	8900000 00300	ASTER BAKERIANUS (L.F.) O.HOFFM.	ASTERACEAE
@	**	8900000 01450	ASTER HISP	ASTERACEAE
@	JS	8919000 00500	FELICIA AMELLOIDES (L.) VAS	ASTERACEAE
@	#	8919000 00800	FELICIA AMOENA (SCH.BIP.) LEVYNS SUBSP.STRICTA (DC.)GRAU.	ASTERACEAE
@	#	8919000 02400	FELICIA CYMBALARIAE (AIT.) H.BOL.& WOLLEY-DOD EX ADAMSON & SALTER SUBSP. CYMBALARIAE	ASTERACEAE
@	#	8919000 02500	FELICIA CYMBALARIAE (AIT.) H.BOL.& WOLLEY-DOD EX ADAMSON & SALTER SUBSP. IONORS (HARV.) GRAU.	ASTERACEAE
@	#	8919000 04000	FELICIA FERULACEA COMPTON	ASTERACEAE
@	JS	8919000 04100	FELICIA FILIFOLIA (VENT.) BURTT-DAVY	ASTERACEAE
@	JS	8919000 06900	FELICIA MURICATA (THUNB.) NEES.	ASTERACEAE
@	#	8919000 08200	FELICIA SCABRA (DC.) RANGE	ASTERACEAE
@	#	8919000 05200	FELICIA HISPIDA (DC.) GRAU.	ASTERACEAE
@	#	8919000 08600	FELICIA TENELLA (L.) NEES SUBSP.COTULOIDES (DC.) GRAU.	ASTERACEAE
@	#	8919000 99999	FELICIA SP.	ASTERACEAE
@	*	8921000 00100	CONYZA MESPILIFOLIA (LESS.) B.L. ROBINSON	ASTERACEAE
	DU	8921000 00000	CONYZA PYRIFOLIA (LAM.) O. KUNTZE.	ASTERACEAE
@	*	8926000 00200	CONYZA SCABRIDA DC.	ASTERACEAE
@	#	8930000 00030	CHRYSOCOMA CANDELABRUM E.BAYER	ASTERACEAE
@	**	8930000 01200	CHRYSOCOMA TENUIFOLIA	ASTERACEAE
@	**	8930000 99999	CHRYSOCOMA SP.	ASTERACEAE
	*	8936000 00100	BRACHYLEANA DISCOLOR DC.	ASTERACEAE
@	**	8937000 00100	TARCHONANTHUS CAMPHORATUS L.	ASTERACEAE
@	*	8949000 00100	DENEKIA CAPENSIS THUNB.	ASTERACEAE
@	*	8967000 01200	IFLOGA VERTICILLATA THUNB.	ASTERACEAE
@	JS	8992000 00550	GNAPHALIUM LUTEO-ALBUM	ASTERACEAE
@	JS	8992000 02200	GNAPHALIUM UNDULATA	ASTERACEAE
	#	8992040 00100	PLECOSTACHYS POLIFOLIA	ASTERACEAE
	DU	8997000 00100	PHAENOCOMA PROLIFER (L.) DON.	ASTERACEAE
@	#	8997000 00025	LASIOPOGON BRACHYRIERUS O.HOFFM.EX ZAHLAR.	ASTERACEAE
@	#	8992020 00500	TRIGLOPHYTON PARVULUM (HARV.) HILLIARD & BURTT.	ASTERACEAE
@	#	9000000 00500	HELIPTERUM CANESCENS (L.) DC.	ASTERACEAE
@	#	9000000 00600	HELIPTERUM DREGEANUM DC.	ASTERACEAE
@	#	9000000 00800	HELIPTERUM FERRUGINEUM (LAM.) SOND.& HARV.	ASTERACEAE
@	#	9000000 00900	HELIPTERUM FLAVUM COMPTON	ASTERACEAE
@	#	9000000 01900	HELIPTERUM VARIEGATUM (THUNB.) DC.	ASTERACEAE
@	#	9000000 02000	HELIPTERUM VIRIGETUM THUNB.	ASTERACEAE
@	**	9006000 00100	HELICHRYSUM ADENOCARPUM DC.	ASTERACEAE
	*	9006000 01000	HELICHRYSUM ANOMALUM LESS.	ASTERACEAE
@	*	9006000 01100	HELICHRYSUM APPENDICULUM (L.F.) LESS.	ASTERACEAE
@	*	9006000 01600	HELICHRYSUM ARGYROPHYLLUM DC.	ASTERACEAE
@	#	9006000 04000	HELICHRYSUM CYLINDRIFLORUM (L.) HILLIARD & BURTT.	ASTERACEAE
@	**	9006000 04100	HELICHRYSUM CYMOSUM (L.) D.DON.	ASTERACEAE
	DU	9006000 00000	HELICHRYSUM DENSIFLORUM OLIV.	ASTERACEAE
@	**	9006000 04800	HELICHRYSUM DREGEANUM SOND. & HARV.	ASTERACEAE
@	**	9006000 06500	HELICHRYSUM FOETIDUM L. MOENCH	ASTERACEAE
@	**	9006000 07200	HELICHRYSUM GLOMERATUM KLATT.	ASTERACEAE
@	*	9006000 07730	HELICHRYSUM HELIANTHEMIFOLIUM (L.) D.DON.	ASTERACEAE
@	**	9006000 10200	HELICHRYSUM LUCIOIDES LESS.	ASTERACEAE

	TH	9006000	10900	HELICHRYSUM MICONIFOLIUM	ASTERACEAE
	*	9006000	12100	HELICHRYSUM NUDIFOLIUM (L.) LESS.	ASTERACEAE
@	**	9006000	12700	HELICHRYSUM ODORATISSIMUM (L.) SWEET.	ASTERACEAE
@	**	9006000	15900	HELICHRYSUM ROSUM (BERG.) LESS.	ASTERACEAE
@	*	9006000	15950	HELICHRYSUM RUGULOSUM	ASTERACEAE
@	#	9006000	16000	HELICHRYSUM RUTILANS LESS.	ASTERACEAE
	TH	9006000	16900	HELICHRYSUM SETOSUM	ASTERACEAE
	TH	9006000	17700	HELICHRYSUM SQUAMOSUM	ASTERACEAE
@	*	9006000	18200	HELICHRYSUM SUBGLOMERATUM LESS.	ASTERACEAE
@	#	9006000	19000	HELICHRYSUM TERETIFOLIUM (L.) D.DON.	ASTERACEAE
@	#	9006000	01915	HELICHRYSUM TINCTUM (THUNB.) HILLIARD & BURTT.	ASTERACEAE
	**	9006000	20455	HELICHRYSUM VERTICILLIATA LESS.	ASTERACEAE
@	**	9006000	21200	HELICHRYSUM ZEYHERI LESS.	ASTERACEAE
@	**	9006000	99999	HELICHRYSUM SP.	ASTERACEAE
@	#	9037000	01400	STOEBE INTRICATA LEVYNS	ASTERACEAE
@	**	9037000	00700	STOEBE LEUCOCEPHALA DC.	ASTERACEAE
@	**	9037000	03300	STOEBE VULGARIS LEVYNS	ASTERACEAE
@	#	9032000	00200	DISPARAGO ERICOIDES GAERTN.	ASTERACEAE
@	#	9041000	00400	ELYTROPAPPUS GNAPHALOIDES (L.) LEVYNS.	ASTERACEAE
@	JS	9041000	00700	ELYTROPAPPUS RHINOCEROTIS (L.F.) LESS.	ASTERACEAE
@		9043000	00200	METALASIA AGATHOSMOIDES (L.) LEVYNS.	ASTERACEAE
@	#	9043000	00900	METALASIA CEPHALOTES (THUNB.) LESS.	ASTERACEAE
@	KI	9043000	02100	METALASIA MURICATA (L.) D.DON.	ASTERACEAE
@	#	9043000	03000	METALASIA SERIPHIIFOLIA DC.	ASTERACEAE
@	#	9047500	00200	LACHNOSPERMUM ERICOIDES WILLD.	ASTERACEAE
@	#	9045000	00100	DOLICHOTHRIX ERICOIDES (LAM.) HILLIARD & BURTT.	ASTERACEAE
@	#	9050000	00200	RELHANIA CALYCINA (L.F.) L'HERIT. SUBSP. CALYCINA.	ASTERACEAE
@	#	9050000	00250	RELHANIA CORYMBOSA (H.BOL.) BREMER	ASTERACEAE
@	#	9050000	01100	RELHANIA PUMILA (L.F.) THUNB.	ASTERACEAE
@	#	9050000	01500	RELHANIA SEDIFOLIA (DC.) HARV.	ASTERACEAE
	DU	9050000	00000	RELHANIA STEYNIAE L.	ASTERACEAE
@	**	9051000	00250	ROSENIA HUMILIS (LESS.) BREMER	ASTERACEAE
@	**	9051000	00300	ROSENIA OPPOSITIFOLIA DC.	ASTERACEAE
@	#	9051000	00400	ROSENIA SPINESCENS DC.	ASTERACEAE
@	#	9052000	00100	LEYSERA GNAPHALOIDES (L.) L.	ASTERACEAE
	TH	9053000	00300	MACOWANIA GLANDULOSA	ASTERACEAE
	TH	9055000	00600	ATHRIXIA FONTANA	ASTERACEAE
@	*	9055000	00900	ATHRIXIA PHYLICOIDES DC.	ASTERACEAE
	DU	9058000	00100	ARROWSMITHIANA STYPHELOIDES DC.	ASTERACEAE
@	**	9073000	00550	PEGOLETTA POLYGALAEFOLIA	ASTERACEAE
@	JS	9090000	00150	GEIGARIA AFRICANA	ASTERACEAE
@	**	9090000	02100	GEIGARIA ORNATIVA O.HOFFM.	ASTERACEAE
	DU	9094000	00200	CALLILEPIS LAUREOLA DC.	ASTERACEAE
@	**	9311000	00200	TAGETES MINUTA L.	ASTERACEAE
@	#	9320000	00100	ERIOCEPHALUS AFRICANUS L.	ASTERACEAE
@	#	9320000	00200	ERIOCEPHALUS ASPALATHOIDES L.	ASTERACEAE
@	**	9320000	00600	ERIOCEPHALUS ERICOIDES (L.F.) DRUCE	ASTERACEAE
@	**	9320000	00700	ERIOCEPHALUS EXIMUS DC.	ASTERACEAE
@	KI	9320000	01700	ERIOCEPHALUS PUNCTULATUS DC.	ASTERACEAE
@	#	9320000	01800	ERIOCEPHALUS RACEMOSUS L.	ASTERACEAE
@	**	9320000	02200	ERIOCEPHALUS SPINESCENS BURCH.	ASTERACEAE
@	#	9321000	00300	LASIOSPERMUM PEDUNCULARE LAG.	ASTERACEAE
	**	9321000	99999	LASIOSPERMUM SP.	ASTERACEAE
@	**	9326000	00800	ATHANASIA DENTATA L.	ASTERACEAE
@	**	9326000	01200	ATHANASIA DREGEANA (DC.) HARV.	ASTERACEAE
@	#	9326000	01500	ATHANASIA FLEXUOSA THUNB.	ASTERACEAE
@	*	9326000	02200	ATHANASIA LINIFOLIA HARV.	ASTERACEAE

@	#	9326000	02400	ATHANASIA MICROPHYLLA DC.	ASTERACEAE
@	#	9326000	03875	ATHANASIA SCHIZOLEPIS HARV.	ASTERACEAE
@	#	9326000	99999	ATHANASIA SP.	ASTERACEAE
	DU	9336000	00000	PHYMASPERMUM ACICULARE BENTH & HOOK F.	ASTERACEAE
@	**	9336000	00300	PHYMASPERMUM PARVIFOLIUM DC. BENTH.& HOOK.	ASTERACEAE
@	#	9337000	00100	LIDBECKIA LOBATA THUNB.	ASTERACEAE
@	**	9340000	00100	LEPIDOSTEPHIUM DENTICULATUM OLIV.	ASTERACEAE
@	**	9351000	01000	COTULA HETEROCARPA DC.	ASTERACEAE
@	**	9351000	02850	COTULA TURBINATA	ASTERACEAE
@	**	9351000	99999	COTULA SP.	ASTERACEAE
	DU	9356000	00100	SCHISTOSTEPHIUM ARTEMISIIFOLIUM BAK.	ASTERACEAE
@	#	9358000	00400	ARTEMISIA VULGARIS	ASTERACEAE
@	#	9357000	00700	HIPPIA PILOSA (BERG.) DRUCE.	ASTERACEAE
@	#	9366000	00600	PENTZIA CALCAREA KIESS.	ASTERACEAE
@	**	9366000	01600	PENTZIA INCANA (THUNB.) KUNTZE.	ASTERACEAE
@	**	9366000	02400	PENTZIA PUNCTATA HARV.	ASTERACEAE
@	**	9366000	02500	PENTZIA QUINQUEFOLIA (THUNB.) LESS.	ASTERACEAE
@	**	9366000	02900	PENTZIA SPINESCENS LESS.	ASTERACEAE
@	**	9369000	00100	STILPNOPHYTUM LINIFOLIUM LESS.	ASTERACEAE
@	**	9377000	00100	HERTIA ALATA (THUNB.) KUNTZE.	ASTERACEAE
@	#	9377000	00200	HERTIA CILIATA (HARV.) KUNTZE	ASTERACEAE
@	#	9385000	00100	STILPNOGENE ALCHEMILLOIDES DC.	ASTERACEAE
@	**	9406000	00300	CINERARIA ASPERA THUNB.	ASTERACEAE
@	FH	9406000	01500	CINERARIA GERANIFOLIA DC.	ASTERACEAE
	*	9406000	01900	CINERARIA LOBATA L'HERIT	ASTERACEAE
@	#	9406000	02500	CINERARIA MITELLIFOLIA L'HERIT	ASTERACEAE
@	**	9406000	03000	CINERARIA PLATYCARPA DC.	ASTERACEAE
@	*	9406000	03200	CINERARIA TOMENTOSUM LESS.	ASTERACEAE
@	#	9411000	01650	SENECIO AMABILIS DC.	ASTERACEAE
@	*	9411000	01700	SENECIO ANGULATUS L.F.	ASTERACEAE
@	**	9411000	01800	SENECIO ANGUSTIFOLIUS (THUNB.) WILLD.	ASTERACEAE
@	#	9411000	02200	SENECIO ARENARIUS THUNB.	ASTERACEAE
@	**	9411000	02400	SENECIO ARTICULATUS (L.)SCH.BIP.	ASTERACEAE
@	**	9411000	02500	SENECIO ASPERULUS DC .	ASTERACEAE
	TH	9411000	03600	SENECIO BREVIDENTATUS	ASTERACEAE
	TH	9411000	04100	SENECIO BUPLEUROIDES	ASTERACEAE
@	**	9411000	05700	SENECIO CONC.	ASTERACEAE
@	**	9411000	06500	SENECIO COTYLEDONIS DC.	ASTERACEAE
	DU	9411000	00000	SENECIO ELONGENSIS TH. FRIES.	ASTERACEAE
@	#	9411000	08900	SENECIO ERIOBASIS DC.	ASTERACEAE
@	#	9411000	09000	SENECIO EROSUS L.F.	ASTERACEAE
@	*	9411000	09200	SENECIO ERUBESCENS AIT.	ASTERACEAE
@	#	9411000	11600	SENECIO GRANDIFLORUS BERG.	ASTERACEAE
@	KI	9411000	12400	SENECIO HAWORTHII (SWEET) SCH.BIP.	ASTERACEAE
@	JS	9411000	13100	SENECIO INAEQUIDENS DC.	ASTERACEAE
	**	9411000	15500	SENECIO LONGIFOLIUS L.	ASTERACEAE
@	**	9411000	15820	SENECIO MACROCARPA	ASTERACEAE
@	**	9411000	16200	SENECIO MADAGASCARIENSIS POIR.	ASTERACEAE
@	**	9411000	18000	SENECIO NAPIFOLIUS MACOHAN.	ASTERACEAE
@	#	9411000	19100	SENECIO PANICULATUS BERG.	ASTERACEAE
@	*	9411000	20400	SENECIO PINNULATUS THUNB.	ASTERACEAE
@	*	9411000	21500	SENECIO PTEROPHORUS DC.	ASTERACEAE
@	#	9411000	25000	SENECIO SOPHIOIDES DC.	ASTERACEAE
@	*	9411000	25100	SENECIO SPECIOSUS WILLD.	ASTERACEAE
	TH	9411000	25100	SENECIO SPECIOSUS WILLD.	ASTERACEAE
@	**	9411000	25400	SENECIO STRATIFOLIUS DC.	ASTERACEAE
@	**	9411000	99999	SENECIO SP.	ASTERACEAE

@	*	9417000	00100	EURYOPS ABROTANIFOLIUS (L.) DC.	ASTERACEAE
@	*	9417000	02400	EURYOPS DYERI HUTCH.	ASTERACEAE
@	#	9417000	04000	EURYOPS IMBRICATUS (THUNB.) DC.	ASTERACEAE
@	#	9417000	06600	EURYOPS OTHONNOIDES (DC.) B.NORD.	ASTERACEAE
@	#	9417000	08000	EURYOPS SPECIOSISSIMUS DC.	ASTERACEAE
@	#	9417000	08600	EURYOPS TAGETOIDES (DC.) B.NORD.	ASTERACEAE
@	*	9417000	08800	EURYOPS TENUISSIMUS (L.) DC.	ASTERACEAE
@	JS	9417000	09800	EURYOPS VIRGINEUS (L.F.) DC.	ASTERACEAE
@	#	9417000	09900	EURYOPS WAGENERI COMPTON	ASTERACEAE
@	#	9418000	00100	GYMNODISCUS CAPILLARIS (L.F.) LESS.	ASTERACEAE
@	#	9420000	00150	OTHONNA ALATA L.	ASTERACEAE
@	#	9420000	00200	OTHONNA ALBA COMPTON	ASTERACEAE
@	#	9420000	00900	OTHONNA AURICULIFOLIA LICHT.EX LESS.	ASTERACEAE
@	*	9420000	01600	OTHONNA CARNOSA LESS VAR. CARNOSA	ASTERACEAE
@	**	9420000	02900	OTHONNA ERIOCARPA DC.	ASTERACEAE
@	#	9420000	03400	OTHONNA FURCATA (LINDL.) DRUCE.	ASTERACEAE
@	#	9420000	04100	OTHONNA HUMILIS SCHLTR.	ASTERACEAE
@	#	9420000	05400	OTHONNA MULTICAULIS HARV.	ASTERACEAE
@	**	9420000	06100	OTHONNA PAVONIA E.MEY	ASTERACEAE
@	#	9420000	07750	OTHONNA RIGENS (L.) LEVYNS	ASTERACEAE
@	**	9420000	99999	OTHONNA SP.	ASTERACEAE
@	**	9425000	00200	DIMORPHOTHECA CUNEATA (THUNB.) LESS.	ASTERACEAE
@	**	9425000	99999	DIMORPHOTHECA SP.	ASTERACEAE
@	#	9425010	00100	CASTALIS NUDICAULIS (L.) T.NORL. VAR. GRAMINIFOLIA (L.) T.NORL.	ASTERACEAE
@	*	9426000	00200	GARULEUM BIPINNATUM (THUNB.) LESS.	ASTERACEAE
	DU	9426000	00400	GARULEUM SCHINZII O.HOFFM.	ASTERACEAE
@	**	9427000	00400	OSTEOSPERMUM AMPLECTENS (HARV.) T.NORL.	ASTERACEAE
@	**	9427000	01300	OSTEOSPERMUM CALENDULACEUM L.F.	ASTERACEAE
@	**	9427000	02600	OSTEOSPERMUM GRANDIFLORUM DC.	ASTERACEAE
@	#	9427000	03150	OSTEOSPERMUM IMBRICATUM L.SUBSP.IMBRICATUM.	ASTERACEAE
@	**	9427000	04200	OSTEOSPERMUM MICROPHYLLUM DC.	ASTERACEAE
@	#	9427000	05100	OSTEOSPERMUM POLYGALOIDES L.VAR. POLYGALOIDES	ASTERACEAE
@	**	9427000	05900	OSTEOSPERMUM SCARIOSUM DC. VAR SCARIOSUM	ASTERACEAE
@	**	9427000	06100	OSTEOSPERMUM SPINESCENS DC.	ASTERACEAE
@	**	9427000	06300	OSTEOSPERMUM SINUATUM (DC.) T.NORL.	ASTERACEAE
@	#	9427000	99999	OSTEOSPERMUM SP.	ASTERACEAE
@	#	9431000	00300	URSINIA ANTHEMOIDES (L.) POIR. SUBSP. ANTHEMOIDES.	ASTERACEAE
@	#	9431000	00400	URSINIA ANTHEMOIDES (L.) POIR.SUBSP.VERSICOLOR (DC.) PRASSLER.	ASTERACEAE
@	#	9431000	00800	URSINIA CHRYSANTHEMOIDES (LESS.) HARV.	ASTERACEAE
@	#	9431000	01000	URSINIA CRITHMOIDES (BERG.) POIR.	ASTERACEAE
@	#	9431000	01900	URSINIA MACROPODA (DC.) N.E.BR.	ASTERACEAE
@	#	9431000	00250	URSINIA NANA DC. SUBSP.NANA.	ASTERACEAE
@	#	9431000	03000	URSINIA PUNCTATA (THUNB.) N.E.BR.	ASTERACEAE
@	#	9431000	03300	URSINIA RIGIDULA (DC.)N.E.BR.	ASTERACEAE
@	#	9431000	03700	URSINIA SERICA (THUNB.) N.E.BR.	ASTERACEAE
@	#	9431000	04000	URSINIA SUBFLOSCULOSA (DC.) PRASSLER	ASTERACEAE
@	#	9432000	00100	ARCTOTIS ACAULIS L.	ASTERACEAE
@	FH	9432000	00700	ARCTOTIS ARCTOTIOIDES (L.F.) O.HOFFM.	ASTERACEAE
@	#	9432000	00900	ARCTOTIS ASPERA L.VAR.ASPERA	ASTERACEAE
@	#	9432000	03300	ARCTOTIS LEICARPA HARV.	ASTERACEAE
@	#	9432000	03850	ARCTOTIS PERFOLIATA (LESS.) BEAUV.	ASTERACEAE
@	#	9432020	00400	ARCTOTHECA REPENS WENDL.	ASTERACEAE
@	*	9432030	00500	HAPLOCARPA SCABIOSA HARV.	ASTERACEAE
@	**	9434000	00300	GAZANIA HETEROCHAETA DC.	ASTERACEAE
@	**	9434000	00400	GAZANIA JURINEIFOLIA DC. SUBSP. JURINEIFOLIA	ASTERACEAE

@	**	9434000 00700	GAZANIA KREBSIANA LESS.	ASTERACEAE
@	**	9434000 01000	GAZANIA LICHTENSTEINII LESS.	ASTERACEAE
@	**	9434000 01100	GAZANIA LINEARIS (THUNB.) DRUCE	ASTERACEAE
@	**	9434000 99999	GAZANIA SP.	ASTERACEAE
@	**	9435000 00100	HIRPICUM ALIENATUM (THUNB.) DRUCE	ASTERACEAE
@	#	9438000 00700	BERKHEYA BARBATA (L.F.) HUTCH.	ASTERACEAE
	*	9438000 01500	BERKHEYA CARDUOIDES (LESS.) HUTCH.	ASTERACEAE
	*	9438000 03000	BERKHEYA DISCOLOR (DC.) O.HOFFM.& MOSCHL.	ASTERACEAE
	*	9438000 06400	BERKHEYA PURPUREA (DC.) MOST.	ASTERACEAE
@	*	9438010 99999	CUSPIDIA SP.	ASTERACEAE
@	**	9462000 00200	CIRSIUM VULGARE (SAVI.) TEN.	ASTERACEAE
@	*	9561000 00100	TOLPIS CAPENSIS (L.) SCH.BIP.	ASTERACEAE
	*	9572000 00400	HYPOCHOERIS RADIATA L.	ASTERACEAE
@	**	9592000 01200	TARAXACUM OFFICINALE WEBER (SENS.)AIT.	ASTERACEAE
	DU	9900010 00000	AFRACHNERA AMPLA	POACEAE
	DU	9900380 00500	MISCANTHIDIUM JUNCEUM STAPF.	POACEAE
@	#	9900720 00300	CYMPOGON MARGINATUS (STEUD.) STAPF EX BURTT DAVY	POACEAE
	DU	9900730 00300	HYPARRHENIA CYMBARIA	POACEAE
	DU	9900800 00100	HETEROPOGON CONTORTUS	POACEAE
@	#	9900830 00100	THEMEDA TRIANDRA FORSSK.	POACEAE
	DU	9901020 00100	ERIOCHLOA MEYERIANUM (NEES)	POACEAE
	DU	9901040 00300	BRACHIARIA BRIZANTHA STAPF.	POACEAE
	DU	9901150 00150	OPLISMENUS COMPOSITUS (L.) BEAUV.	POACEAE
	DU	9901160 00200	PANICUM AMARUM VAR. AMARUM.	POACEAE
	DU	9901160 01000	PANICUM DEUSTUM THUNB.	POACEAE
	DU	9901160 01000	PANICUM DEUSTUM THUNB.	POACEAE
@	*	9901160 02800	PANICUM MAXIMUM JACQ.	POACEAE
@	#	9901160 03800	PANICUM REPENS L.	POACEAE
	DU	9901160 04300	PANICUM TRICHOCLADUM HACK. EX. ENGL.	POACEAE
	DU	9901380 00250	ANTHEPHORA BUTRTII STAPF. & C.E.HUBBARD	POACEAE
@	#	9901390 00200	PENNISETUM MACROURUM TRIN.	POACEAE
@	#	9901390 01300	PENNISETUM SPHACELATUM (NEES) DUR & SCHINZ.	POACEAE
@	#	9901390 01700	PENNISETUM THUNBERGII KUNTH.	POACEAE
@	**	9901400 00300	CENCHRUS CILIARIS L.	POACEAE
	DU	9901400 00300	CENCHRUS CILIARIS L.	POACEAE
	DU	9901590 00200	LEERSIA HEXANDRA S.W.	POACEAE
	#	9901600 00700	EHRHARTA CAPENSIS THUNB.	POACEAE
@	**	9901600 00600	EHRHARTA CALYCINA J.E.SM.VAR.CALYCINA	POACEAE
@	**	9901600 01000	EHRHARTA DURA NEES EX.TRIX	POACEAE
@	#	9901600 01500	EHRHARTA LONGIFLORA SCHRAD.	POACEAE
@	KI	9901600 02400	EHRHARTA REHMANII STARF.VAR.REHMANNII.	POACEAE
@	#	9901600 03300	EHRHARTA VILLOSA SCHULT.F.VAR.VILLOSA.	POACEAE
@	#	9901640 00200	ANTHOYANTHUM DREGEANUM (NEES) STAPF.	POACEAE
@	#	9901850 00200	AIRA CUPANIANA GUSS.	POACEAE
@	#	9901910 00100	POAGROSTIS PUSILLA (NEES) STAPF.	POACEAE
@	**	9902043 00500	MERXMUELLERA DISTICHA	POACEAE
@	#	9902043 01200	MERXMUELLERA RUFA (NEES) CONERT	POACEAE
@	**	9902043 01400	MERXMUELLERA STRICTA	POACEAE
@	KI	9902050 00300	PENTASCHISTIS AMPLA (NEES) MCCLEAN	POACEAE
@	#	9902050 00400	PENTASCHISTIS ANGULATA (NEES) ADAMSON	POACEAE
@	#	9902050 00600	PENTASCHISTIS ANGUSTIFOLIA (NEES)STAPF	POACEAE
@	KI	9902050 00800	PENTASCHISTIS ANGUSTIFOLIA (NEES) STAPF. VAR. MICRATHERA (NEES) STAPF.	POACEAE
@	#	9902050 00900	PENTASCHISTIS ARISTIDOIDES (THUNB.) STAPF.	POACEAE
@	#	9902050 01100	PENTASCHISTIS ASPERA (THUNB.) STAPF.	POACEAE
@	#	9902050 01800	PENTASCHISTIS COLORATA (STEUD.) STAPF. VAR COLORATA	POACEAE
@	#	9902050 01900	PENTASCHISTIS COLORATA (STEUD.) STAPF VAR.POLYRICHA STAPF.	POACEAE

@	#	9902050	02000	PENTASCHISTIS CURVIFOLIA (SCHRAD.)	POACEAE
@	#	9902050	02100	PENTASCHISTIS DENSIFOLIA (NEES) STAPF. VAR.DENSIFOLIA	POACEAE
@	#	9902050	02300	PENTASCHISTIS ELEGENS (NEES) STAPF.	POACEAE
@	#	9902050	02400	PENTASCHISTIS ERIOSIOMA (NEES) STAPF.	POACEAE
@	KI	9902050	03500	PENTASCHISTIS MALOUINENSIS (STEUD.) CLAYTON	POACEAE
@	KI	9902050	03600	PENTASCHISTIS MICROPHYLLA (NEES.) MCCLEAN	POACEAE
@	#	9902050	04000	PENTASCHISTIS PALLESCENS (SCHRAD.) STAPF.	POACEAE
@	#	9902050	06000	PENTASCHISTIS VISCIDULA (NEES) STAPF.	POACEAE
@	#	9902050	99999	PENTASCHISTIS SP.	POACEAE
@	#	9902080	00100	PENTAMERIS DREGEANA STAPF.	POACEAE
@	#	9902080	00300	PENTAMERIS MACROCALYCINA (STEUD.) SCHWEICK.	POACEAE
@	#	9902080	99999	PENTAMERIS SP.	POACEAE
@	#	9902081	00100	PSEUDOPENTAMERIS BRACHYPHYLLA (STAPF.) CONERT.	POACEAE
@	JS	9902430	00900	AGROSTIS LACHNANTHA NEES.	POACEAE
@	#	9902440	00400	POLYPOGON MONSPELIENSIS (L.)DESF.	POACEAE
@	**	9902611	03200	STIPAGROSTIS UNIPLUMIS (LICHT.) DE WINTER	POACEAE
@	**	9902620	01300	ARISTIDA DIFFUSA TRIN.	POACEAE
@	#	9902620	02000	ARISTIDA JUNCIFORMIS TRIN.& RUPR. SUBSP. JUNCIFORMIS	POACEAE
@	**	9902620	99999	ARISTIDA SP.	POACEAE
@	#	9902830	03600	SPOROBOLUS VIRGINICUS (L.) KUNTH.	POACEAE
@	**	9902830	99999	SPOROBOLUS SP.	POACEAE
@	**	9902860	01100	EROGROSTIS BICOLOR NEES	POACEAE
@	#	9902860	01500	EROGROSTIS CAPENSIS (THUNB.) TRIN.	POACEAE
@	**	9902860	01800	EROGROSTIS CILIANENSIS (AIT.) F.T.HUBB.	POACEAE
@	**	9902860	02300	EROGROSTIS CURVULA (SCHRAD.) NEES.	POACEAE
@	**	9902860	04300	EROGROSTIS LEHMANNIANA NEES.	POACEAE
@	**	9902860	06300	EROGROSTIS PROCUMBENS NEES.	POACEAE
@	#	9902860	07400	ERAGROSTIS SAPMENTOSA (THUNB.) TRIN.	POACEAE
@	KI	9902960	00300	CYNODON DACTYLON (L.) PERS.	POACEAE
@	**	9903270	00100	TETRACHNE DREGEI NEES.	POACEAE
@	**	9903570	00200	ENNEAPOGON DESVAUXII BEAUV.	POACEAE
@	**	9903710	00100	FINGERHUTHIA AFRICANA LEHM.	POACEAE
@	**	9903710	00200	FINGERHUTHIA SESLERIFORMIS NEES.	POACEAE
	DU	9903740	00060	KOELERIA CRISTATA PERS.	POACEAE
	DU	9903800	00500	MISCANTHIDIUM JUNCEUM	POACEAE
	DU	9903881	00100	MEGASTACHYUS MUCRONATA (POIR.) C.E.H.	POACEAE
@	#	9903990	00100	LASIOCHLOA ECHINATA (THUNB.) ADAMSON.	POACEAE
@	#	9903990	00200	LASIOCHLOA LONGIFOLIA (SCHRAD.) KUNTH.	POACEAE
@	#	9904020	00300	PLAGIOCHLOA BRACHYSTACHYA (NEES.) ADAMSON & SPRAGUE	POACEAE
@	#	9904020	00550	PLAGIOCHLOA UNIOLAE (L.F.) ADAMSON & SPRAGUE VAR.VILLOSA (STAPF.) ADAMSON	POACEAE
@	JS	9904050	00100	SCHISMUS BARBATUS (LOEFL.EX.L.)THELL.	POACEAE
	DU	9904070	00400	POA BINATA NEES.	POACEAE
	DU	9904070	00550	POA LEPTOCHLADA H.	POACEAE
@	#	9904070	00700	POA VIVIPARA (L.) WILLD.	POACEAE
	DU	9904100	00100	COLPODIUM HEDBERGII (MELD.) TZXEL.	POACEAE
@	#	9904150	00300	PUCCINELLA FASCICULATA L.	POACEAE
@	#	9904170	01000	FESTUCA SCABRA VAHL.	POACEAE
@	#	9904180	00100	VULPIA BROMOIDES (L.) S.F.	POACEAE
@	**	9904280	00600	BROMIS JAPONICUS THUNB.	POACEAE
@	**	9904510	00320	HORDEUM MURINUM L.	POACEAE

APPENDIX G.

STATISTICAL BACKGROUND TO MDA.

Notation and description follow Nie et al. (1975), Liu and Lam (1985) and MacDonald and Ritchie (1986). Discriminant analysis tries to statistically distinguish between two or more groups or samples. Discriminant functions are formed to achieve this. These functions are linear combinations of variables (taxa) and are formed to minimise separation between groups relative to variation within groups. They are of the form :

$$D_i = d_{il}z_1 + d_{i2}z_2 + \ldots\ldots + d_{ip}z_p \qquad (1)$$

where D_i is the score of the discriminant function i, the d's are weighting coefficients and the z's are the standardised values of the p discriminating variables. The discriminant scores (D) from the cases in one group should be similar. The maximum number of discriminant functions derived is either one or less than the number of groups or equal to the number of discriminating variables. A stepwise procedure is employed in this analysis to test the significance of the discriminating variables. The probability of group membership is compared on the basis of the distance between the case (pollen sample) and the centroid of each a priori group. The probability is represented by $p(H_k/X_i)$, the probability of case i belonging to group k, given the values in i of the m variables $(X_{1i}, X_{2i}, \ldots\ldots, X_{mi})$. This is calculated by :

$$g_{ik} = \log P_k - {}^1/_2(\log/D_k/ + X_{ik}^2) \qquad (2)$$

where P_k is the prior probability for membership in group k. $/D_k/$ represents the determinant of the within-group variance-covariance matrix of groups k and X_{ik}^2 and is computed by :

$$X_{ik}^2 = d_{ik}D^{-1}d_{ik} \qquad (3)$$

where D^{-1} is the inverse of the pooled within-group variance-covariance matrix, and d_{ik} is the vector containing the difference between sample i and the centroid of group k.

The probability of group membership is then computed :

$$P(H_k/X_i) = \frac{\exp\,(g_{ik} - \underline{\max\, g_{ik}})}{\sum_{k-1}^{g} \exp\,(g_{ik} - \underline{\max\, g_{ik}})} \qquad (4)$$

The sum of the probabilities for the group membership of each sample i is equal to unity. SPSS (Nie et al., 1975) assign the sample to group k to which its probability of membership is highest. The results in every sample are assigned to a group.

The probability of group membership is assessed by calculating the probability of modern analogue index, denoted as $P(X_i/H_k)$. This probability represents the proportion of samples among members of group k which are ordinated in the vicinity of sample i. This is

determined by first calculating the chi-squared distance between sample i and centroid of group k in equation 3. X^2_{ik} has a chi-squared distribution with m degrees of freedom and $P(X_i/H_k)$ is the significance level of such a X^2_{ik}. $P(X_i/H_k)$ measures the similarity of sample i in group k with other samples in the same group.

APPENDIX H.

LIST OF RADIOCARBON DATES.

SITE	*DEPTH*	*RADIOCARBON DATE*	*LAB. NO*
Winterberg,			
Ellerslie Vlei	155cm	4 200 ± 60 BP	Pta-4335
Sneeuberg,			
Compassberg	95cm	3 590 ± 70 BP	Pta-4342
Nuweveldberg,			
Bokkraal Vlei	120cm	760 ± 50 BP	Pta-4351
Cederberg,			
Sneeuberg Vlei	63cm	1 990 ± 80 BP	Pta-5029
Sneeuberg Vlei	133cm	3 310 ± 90 BP	Pta-5007
Sneeuberg Vlei	310cm	9 640 ± 70 BP	Pta-4522
Driehoek Vlei	265cm	3 230 ± 70 BP	Pta-4831
Driehoek Vlei	460cm	10 090 ± 100 BP	Pta-4759
Driehoek Vlei	520cm	14 600 ± 290 BP	Pta-4523

APPENDIX I.

ORGANIC CONTENT - WALKLEY BLACK METHOD.

	%C	% Organic Matter	Mean
NUWEVELDBERG CORE.			
0 - 20 cm	8.775	15.128	
20 - 40 cm	7.136	12.303	
40 - 60 cm	8.100	13.964	x = 13.068%
60 - 80 cm	7.528	12.979	
80 - 100 cm	7.800	13.447	
100 - 120 cm	6.143	10.589	
SNEEUBERG CORE.			
65 - 70 cm	5.141	8.863	
85 - 90 cm	3.582	6.175	x = 7.519%
WINTERBERG CORE.			
0 - 20 cm	8.977	15.478	
20 - 40 cm	8.201	14.138	
40 - 60 cm	9.568	16.495	
60 - 80 cm	7.582	13.071	
80 - 100 cm	7.200	12.413	x = 12.655%
100 - 120 cm	6.139	10.584	
120 - 140 cm	5.936	10.235	
140 - 160 cm	5.119	8.824	
DRIEHOEK CORE.			
0 - 20 cm	11.100	19.140	
20 - 80 cm	7.999	13.790	
140 - 180 cm	12.900	22.240	
205 - 220 cm	7.802	13.450	
220 - 270 cm	6.299	10.860	x = 15.43%
320 - 350 cm	7.430	12.810	
350 - 385 cm	6.259	10.990	
400 - 440 cm	10.881	18.760	
445 - 475 cm	7.720	13.310	
510 - 520 cm	10.992	18.950	
SNEEUBERG CORE.			
0 - 15 cm	12.517	21.580	
15 - 45 cm	12.749	21.980	
45 - 80 cm	11.642	20.070	
80 - 95 cm	9.832	16.950	
95 - 105 cm	8.892	15.330	x = 18.798%
105 - 130 cm	9.710	16.740	
130 - 200 cm	9.884	17.040	
200 - 225 cm	9.977	17.200	
225 - 290 cm	10.882	18.760	
290 - 310 cm	12.929	22.290	

APPENDIX J.

(All data represented as a percentage of the pollen sum.)

1. WINTERBERG: ELLERSLIE FOSSIL POLLEN DATA.

Depth (cm)	00	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	105	110	115	120	125	130	135	140	145	150	155	160
Poaceae	17.0	15.0	14.0	13.0	10.4	18.2	17.8	12.8	16.0	18.5	17.0	13.0	13.7	13.3	12.6	16.4	16.9	16.7	18.0	16.5	16.1	13.6	13.2	10.8	13.9	17.3	12.6	14.3	11.8	10.2	15.2
Cyperaceae	8.0	6.5	7.3	5.8	8.4	10.2	9.4	7.9	7.5	9.1	10.0	5.2	7.7	8.1	5.9	7.6	6.7	7.3	6.2	7.3	5.4	4.9	5.5	5.7	5.9	8.4	7.1	7.4	5.0	7.1	8.9
Aizoaceae	1.4	0.4	0.5	0.6	0.5	0.2	0.5	0.4	0.7	0.5	0.1	0.4	0.6	0.0	0.0	0.0	0.2	0.2	0.2	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0
Campanulaceae	2.5	2.8	1.6	2.0	2.3	2.1	1.2	2.4	2.0	2.7	2.4	3.7	2.4	3.7	3.6	2.7	1.8	1.8	1.8	1.2	1.7	2.5	2.2	1.1	1.1	2.0	2.3	1.0	1.1	0.5	0.6
Caryophyllaceae	0.8	0.6	0.6	0.2	0.3	0.4	0.1	0.2	0.0	0.4	0.4	0.0	0.5	0.5	0.4	0.4	0.0	0.2	0.0	0.0	0.5	0.4	0.1	0.1	0.2	0.4	0.0	0.2	0.0	0.3	0.0
Iridaceae	1.4	1.6	2.5	1.8	2.7	1.4	1.7	1.3	2.2	1.6	1.2	1.3	1.0	0.6	0.9	1.6	1.0	8.4	1.5	0.7	1.6	1.8	1.4	1.7	1.1	1.2	1.2	1.6	1.6	0.9	0.8
Malvaceae	0.6	0.6	0.6	0.7	0.7	0.6	0.7	0.9	0.8	0.1	0.0	1.1	0.7	0.0	0.7	0.4	0.2	0.2	0.5	0.5	1.5	0.8	1.0	0.8	2.2	1.3	0.7	0.9	0.6	0.8	0.8
Plantaginaceae	1.9	2.0	1.9	1.4	2.2	2.2	2.1	2.5	1.4	2.0	1.2	1.5	1.1	0.6	2.3	1.3	1.7	0.9	1.4	2.4	1.6	2.9	1.5	2.0	0.4	1.9	1.9	1.0	2.8	2.4	3.4
Polygonaceae	3.6	3.8	3.1	3.2	4.0	2.7	1.8	1.5	1.7	2.8	1.7	2.0	1.5	2.0	2.8	1.7	2.0	1.7	1.7	1.3	1.1	0.7	2.9	2.4	3.3	1.9	2.4	2.1	2.8	2.0	1.9
Ranunculaceae	3.4	7.0	5.6	5.8	6.2	5.7	6.7	6.5	7.2	5.4	6.2	7.4	7.3	7.6	4.2	6.5	7.1	7.6	7.1	7.4	19.8	6.5	5.6	6.5	4.9	1.2	5.7	5.0	6.8	5.3	4.8
Rosaceae	1.3	1.6	1.9	1.8	2.0	1.4	1.7	2.2	2.0	1.5	1.9	2.2	2.2	1.7	1.8	1.6	1.2	1.4	1.9	1.9	1.9	2.2	1.4	1.9	1.8	1.5	2.1	1.8	2.3	3.5	1.4
Scrophulariaceae	1.5	1.6	1.9	3.4	2.4	0.9	1.8	2.2	2.0	2.6	1.3	2.4	1.7	2.7	3.2	1.7	2.5	2.9	2.4	2.1	2.5	2.7	2.6	2.5	3.1	2.5	3.6	3.6	3.4	2.9	2.5
Viscaceae	0.9	2.0	2.3	2.1	1.7	1.3	1.7	1.3	1.4	1.1	1.9	1.8	2.1	1.6	1.9	0.0	1.9	1.9	1.1	1.5	1.8	1.6	1.0	0.4	1.7	1.5	0.6	1.7	1.0	0.8	0.3
Asteraceae	12.5	14.0	14.0	14.9	16.8	13.1	14.2	18.6	5.2	13.1	13.5	16.3	14.8	15.4	19.2	14.5	18.7	13.1	17.9	22.9	18.1	21.4	13.4	16.3	16.1	14.0	12.9	16.2	14.8	19.6	19.4
Acanthaceae	4.5	4.4	4.5	4.4	4.0	3.3	3.2	5.2	2.5	2.5	2.9	3.4	3.2	2.5	2.0	2.4	2.4	2.7	2.9	1.1	1.2	2.0	3.4	4.4	4.1	1.5	2.9	2.5	2.0	0.5	1.4
Bignoniaceae	2.7	1.8	3.4	3.5	2.7	1.3	1.8	1.3	2.0	2.7	3.7	3.5	4.6	3.4	1.4	1.9	1.7	3.2	2.1	1.5	2.4	1.7	2.5	2.4	1.4	2.1	1.7	2.1	1.7	2.0	2.5
Chenopodiaceae	0.5	0.0	0.1	0.1	0.0	0.4	0.6	0.0	0.7	0.1	0.1	0.4	0.2	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Crucifereae	0.5	0.0	0.0	0.0	0.7	0.6	0.6	0.0	0.0	0.0	0.6	0.0	0.1	0.3	0.0	0.6	0.0	0.0	0.0	0.5	0.0	0.0	0.5	0.0	0.0	0.0	0.1	0.2	0.0	0.0	0.0
Ericaceae	1.4	0.8	1.5	1.4	1.2	1.1	1.9	1.4	0.2	1.1	1.9	1.1	1.9	1.6	1.2	0.9	1.0	0.8	0.5	0.7	0.6	0.7	0.7	0.2	0.6	0.2	0.3	0.1	0.1	0.0	0.0
Geraniaceae	1.4	1.2	0.9	1.5	1.7	1.8	1.4	2.7	1.7	1.2	1.4	1.3	2.1	0.8	1.0	1.2	0.7	1.6	0.5	2.6	1.5	1.8	1.9	1.8	1.8	0.7	2.0	1.0	1.1	1.1	1.7
Labiatae	5.7	5.2	5.1	4.9	4.9	2.2	4.9	4.9	3.1	3.7	4.9	3.9	5.1	5.9	6.7	5.6	6.0	6.0	5.9	7.7	5.6	4.7	7.1	8.4	6.1	8.0	8.4	7.6	7.5	9.6	7.6
Liliaceae	4.4	7.0	7.4	5.7	4.2	5.7	5.8	4.0	5.9	5.3	4.2	4.3	5.6	5.3	4.3	5.3	3.3	4.4	4.5	2.4	4.6	4.9	5.6	4.8	5.4	7.6	5.4	6.4	5.2	7.0	7.2
Papaveraceae	0.6	0.0	0.8	1.1	0.5	0.6	0.0	0.7	0.7	1.4	0.0	0.0	0.9	0.6	0.0	0.6	0.7	0.2	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Polygalaceae	1.0	1.0	0.8	1.1	0.7	0.6	0.5	0.7	0.0	0.9	0.4	0.2	0.1	0.3	0.9	0.8	0.9	0.7	0.7	0.7	1.4	0.7	1.4	1.3	0.7	0.6	0.6	0.6	0.6	0.2	0.3
Sterculiaceae	1.5	2.6	2.3	4.1	4.5	3.5	2.4	3.4	2.8	2.7	3.7	3.9	4.0	5.5	4.9	3.8	4.1	4.7	3.9	3.6	3.1	5.2	5.5	4.7	4.7	4.3	5.4	5.7	5.5	6.6	4.5
Tiliaceae	1.2	1.0	1.0	1.1	0.5	1.0	0.3	0.0	0.4	0.1	0.5	0.4	0.7	1.6	0.0	0.4	1.0	0.8	0.5	0.0	0.3	0.4	0.6	0.2	0.4	0.5	1.0	0.9	0.3	0.5	0.0
Thymelaeaceae	0.0	1.6	0.6	1.3	1.2	0.9	1.1	1.3	0.5	0.9	1.4	0.6	1.5	1.6	1.4	1.6	2.2	0.8	2.1	0.7	1.9	2.3	1.5	1.9	2.0	2.5	1.6	0.9	1.3	0.6	0.6
Fabaceae	8.7	8.1	7.3	9.1	5.5	8.4	8.6	9.1	10.1	9.2	10.0	10.8	8.1	8.6	10.3	11.0	7.6	9.9	8.4	7.4	8.8	8.5	11.0	12.0	11.9	9.7	12.1	10.6	10.8	10.1	10.4
Celastraceae	0.1	0.0	0.3	0.1	0.2	0.0	0.7	0.0	0.0	0.4	0.3	0.4	0.1	0.0	0.2	0.2	0.2	0.0	0.0	0.0	0.4	0.1	0.0	0.0	0.5	0.0	0.2	0.0	0.1	0.0	0.0
Oleaceae	1.1	1.2	0.6	0.5	1.4	1.1	1.2	1.4	1.0	1.5	1.3	0.9	1.0	0.8	0.9	1.0	1.0	0.7	0.9	0.3	0.9	0.7	0.6	0.4	0.5	0.0	0.0	0.6	0.7	0.2	0.6
Pinaceae	0.7	0.4	0.4	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Podocarpaceae	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.2	0.0	0.1	0.1	0.7	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Unknown	3.5	2.2	2.8	3.0	2.7	2.6	2.6	3.6	3.6	3.3	3.3	3.8	2.5	2.2	2.5	2.9	2.4	3.4	2.5	3.5	3.3	2.9	3.2	3.8	2.6	2.8	2.7	3.3	2.0	3.6	2.2
Spores	4.2	1.0	0.9	0.8	2.0	1.5	1.8	1.5	0.8	1.1	1.4	1.5	1.0	0.9	0.5	2.0	1.1	1.4	1.5	0.7	1.1	0.8	0.7	0.8	0.9	0.5	1.2	0.4	0.4	0.3	0.6
POLLEN SUM	996	506	778	856	595	715	659	551	581	739	843	537	818	641	571	895	801	859	803	613	796	767	872	843	837	1041	934	813	703	638	356

2. SNEEUBERG: COMPASSBERG FOSSIL POLLEN DATA.

Depth (cm)	30	40	50	55	60	65	70	75	80	85	90	95	155	200	240
Poaceae	23.0	16.0	18.8	22.4	28.0	19.4	27.0	22.2	25.5	29.0	20.0	23.0	27.0	25.0	18.0
Cyperaceae	10.0	5.9	6.7	7.2	11.0	6.2	6.9	8.3	5.1	9.0	9.0	5.9	12.0	21.0	20.0
Juncaceae	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.6	0.9	3.0	0.0	0.0	3.0	7.0
Caryophyllaceae	0.0	0.0	0.0	0.0	2.0	0.0	0.0	0.0	0.8	0.9	0.8	0.6	0.0	0.0	0.0
Iridaceae	1.5	1.2	1.2	0.8	4.0	2.4	0.9	1.4	2.0	1.6	2.0	2.1	0.0	1.5	0.0
Mesems/Aizoaceae	2.0	2.7	3.5	2.3	0.0	1.8	2.7	0.3	1.4	0.3	3.0	0.0	0.0	0.0	0.0
Oxalidaceae	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Polygonaceae	0.9	4.3	1.6	3.0	0.0	4.1	4.8	3.9	4.2	0.0	0.0	4.9	0.0	0.0	0.0
Asteraceae	24.0	23.0	16.3	15.8	14.0	15.3	20.9	19.4	17.8	11.0	10.0	18.2	20.0	6.0	7.5
Acanthaceae	3.4	6.7	5.1	3.4	0.8	4.1	4.2	2.5	4.8	1.6	2.0	1.9	0.0	0.0	0.7
Bignoniaceae	0.9	5.1	6.7	4.9	1.2	5.0	3.3	1.4	0.8	0.3	0.0	1.9	0.0	0.0	0.0
Chenopodiaceae	2.0	1.2	0.8	0.8	0.0	0.6	0.6	0.0	0.3	0.0	1.0	3.4	6.0	1.5	1.5
Ebenaceae	0.0	0.0	0.0	0.0	0.0	0.0	1.5	1.6	1.4	1.9	2.0	1.9	2.0	1.5	3.0
Ericaceae	0.5	0.0	0.0	0.0	0.8	0.0	0.0	0.0	0.0	0.6	3.0	1.2	2.0	3.0	0.0
Euphorbiaceae	0.0	0.0	0.0	0.0	3.0	0.6	0.6	0.6	0.0	2.6	4.0	2.2	0.0	2.0	3.0
Geraniaceae	0.5	3.1	2.7	1.9	0.8	2.1	3.6	2.5	2.3	1.9	0.0	0.9	0.0	0.0	0.7
Labiatae	1.0	5.9	3.5	5.7	0.0	7.4	6.3	3.9	4.5	0.0	0.0	5.9	0.0	0.0	0.0
Liliaceae	3.0	2.0	1.9	1.9	3.0	1.5	1.5	0.8	0.0	2.0	1.5	0.6	0.0	2.0	1.5
Polygalaceae	0.0	0.4	0.0	0.4	0.0	0.0	0.0	0.0	1.1	0.9	1.5	0.0	1.0	1.5	0.0
Sterculiaceae	0.5	1.6	3.5	2.7	0.0	2.9	4.8	3.0	3.4	4.2	1.5	0.3	2.0	4.0	0.7
Tiliaceae	0.0	2.0	1.6	1.5	4.0	3.5	4.6	3.9	5.7	4.2	4.0	4.0	0.0	0.0	4.0
Thymelaeaceae	0.0	0.8	0.8	0.4	2.0	1.8	1.8	2.2	2.0	3.0	5.0	2.5	3.0	4.0	5.0
Fabaceae	11.0	9.8	14.0	12.0	9.6	11.2	6.9	11.9	0.0	9.5	9.0	9.9	8.0	10.0	10.0
Oleaceae	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.3	2.0	0.0	0.0	0.0	4.0
Unknown	10.0	4.3	1.6	1.9	9.6	1.8	3.3	4.4	3.1	8.9	4.7	14.4	12.0	11.0	10.0
Spores	4.0	0.4	0.4	3.8	4.8	0.0	0.0	0.3	0.3	2.2	0.3	2.3	3.0	1.5	0.7
POLLEN SUM	207	255	255	263	250	340	334	361	353	309	322	262	90	134	135

3. NUWEVELDBERG: CONTEMPORARY POLLEN TRAP DATA - 1986.

Trap No.	1	2	3	4	7	8	9	10	11	12	14	16
Poaceae	24.0	19.7	35.0	32.0	0.6	16.0	17.0	18.5	20.0	14.0	24.4	16.0
Cyperaceae	5.0	4.0	4.8	2.6	0.3	13.0	17.0	17.1	11.0	4.3	2.6	2.4
Iridaceae	1.0	0.4	0.0	1.1	0.0	0.9	0.2	2.8	0.6	1.7	1.7	1.7
Liliaceae	0.8	0.4	0.2	0.0	0.0	2.08	2.4	1.1	3.6	0.4	0.4	0.0
Labiatae	0.6	0.5	2.5	1.8	0.0	5.8	6.9	7.5	6.5	1.5	2.6	1.9
Asteraceae	20.0	31.0	7.5	12.3	1.0	9.8	6.7	9.0	13.6	21.3	11.5	23.9
Fabaceae	15.0	12.6	11.2	9.8	0.9	10.6	10.8	13.5	11.0	11.4	8.7	14.2
Ericaceae	3.0	1.3	0.4	1.8	0.1	0.6	0.0	0.2	0.8	0.9	0.0	0.0
Chenopodiaceae	1.4	3.3	3.5	2.2	0.2	1.5	0.4	0.4	0.4	3.9	1.7	4.1
Mesems.	2.0	2.4	2.3	1.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Aizoaceae	2.2	0.4	1.9	1.1	0.0	0.9	0.2	0.2	0.2	6.8	1.9	3.2
Plantaginaceae	2.0	0.7	1.4	1.8	0.0	0.6	0.8	0.8	1.8	0.9	0.4	1.9
Campanulaceae	1.6	2.0	1.9	0.9	0.0	0.9	0.6	0.8	1.6	1.5	0.4	0.9
Caryophyllaceae	0.8	1.1	1.9	0.9	0.0	0.0	0.6	1.5	1.5	0.9	0.0	0.2
Tiliaceae	2.7	1.6	1.4	3.1	0.0	1.7	1.5	2.9	2.8	3.1	1.3	5.2
Thymelaeaceae	3.9	3.7	2.9	2.7	0.0	1.3	0.2	1.5	0.8	1.9	1.5	2.2
Acanthaceae	0.8	1.3	1.0	2.0	0.0	1.7	3.2	1.7	3.5	2.6	2.0	2.6
Bignoniaceae	3.3	2.0	2.9	4.9	0.0	2.8	1.1	2.8	3.0	3.5	1.9	5.2
Rosaceae	2.2	0.5	3.1	3.6	0.0	2.2	0.8	2.5	1.6	1.9	2.3	0.9
Euphorbiaceae	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Malvaceae	1.2	0.7	0.8	1.5	0.1	0.7	0.0	0.4	0.0	0.0	0.2	0.0
Selaginaceae	0.0	0.0	0.0	0.0	0.0	0.6	0.0	0.8	0.6	3.9	1.3	3.5
Geraniaceae	0.4	0.4	1.4	2.7	0.3	0.7	1.7	0.4	0.6	1.7	1.7	1.5
Scrophulariaceae	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0..	0.9	0.0	0.0
Salicaceae	0.8	0.7	0.4	0.0	96.0	7.0	19.0	7.3	5.0	0.0	3.0	0.0
Ranunculaceae	0.0	0.0	0.0	0.0	0.0	2.6	3.2	3.5	3.5	0.0	0.2	0.6
Sterculiaceae	0.2	2.0	4.0	1.5	0.3	1.7	0.6	0.8	1.8	2.2	0.6	0.6
Polygalaceae	0.4	0.4	0.8	0.2	0.0	0.2	0.0	0.4	0.2	0.0	0.4	0.2
Polygonaceae	0.8	0.7	1.2	2.2	0.0	1.5	3.0	1.5	2.8	1.7	1.7	1.9
Pinaceae	1.4	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	1.7	4.9	0.4
Onograceae	0.0	0.0	0.0	1.3	0.0	0.4	0.0	0.0	0.2	0.0	0.0	0.2
Unknown	0.8	0.4	0.8	0.9	0.0	1.1	0.2	0.4	1.6	0.4	0.0	1.3
Spores	0.2	5.4	0.6	3.8	0.0	0.7	1.1	0.0	0.2	0.0	19.7	0.6
POLLEN SUM	490	546	484	549	726	539	464	480	493	458	532	465

3. NUWEVELDBERG: CONTEMPORARY POLLEN TRAP DATA - 1987.

Trap No.	1	2	3	5	6	7	8	10	11	12	13	14	15a	15b	16	17
Poaceae	29.0	19.0	32.0	21.0	24.0	9.0	13.0	15.0	18.0	27.0	22.0	36.0	27.0	23.0	29.0	53.0
Cyperac.	3.0	2.1	3.0	2.3	5.0	3.5	17.0	12.0	14.0	6.0	3.5	1.0	4.0	1.6	2.6	1.6
Iridaceae	0.5	0.4	1.2	1.0	1.0	0.6	0.3	0.0	0.0	0.0	0.6	0.6	0.3	0.0	1.0	0.5
Liliaceae	0.5	0.7	0.5	0.2	0.0	0.0	3.0	2.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Labiatae	0.5	2.1	1.0	1.0	2.5	2.0	4.4	6.0	3.0	2.3	2.0	1.0	2.4	1.0	1.0	1.2
Aster.	32.0	46.0	26.2	40.0	32.0	23.6	25.4	15.7	24.5	19.6	28.6	32.0	30.9	48.0	35.7	17.0
Fabaceae	10.0	8.0	13.2	9.4	9.9	4.9	9.0	16.2	13.9	16.9	13.7	12.0	14.2	29.0	16.0	8.9
Erica.	1.3	1.5	1.7	1.0	0.7	0.6	1.3	0.2	0.6	0.3	0.3	0.0	0.0	0.0	0.0	0.0
Chenopod.	2.3	3.0	3.0	1.6	1.3	3.0	1.0	1.0	1.2	3.8	5.0	3.5	3.2	1.6	4.2	1.8
Mesems.	0.8	0.4	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.6	0.0	0.0	0.5	0.0	0.0
Aizoaceae	2.8	2.4	1.5	1.6	2.2	0.0	0.0	0.0	0.0	3.2	2.3	0.3	1.2	2.0	1.6	1.0
Plantag.	1.8	1.1	1.7	2.0	3.3	2.0	1.0	2.4	0.3	2.0	3.8	0.3	1.8	1.0	1.0	1.6
Campan.	0.5	0.6	0.0	0.0	0.7	0.0	0.0	2.0	0.6	1.4	0.0	0.0	0.0	0.0	0.0	0.9
Caryoph.	0.5	0.2	0.0	0.0	0.0	0.0	2.3	1.5	1.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tiliaceae	0.5	1.1	0.5	0.4	0.5	1.5	0.3	0.2	0.0	0.3	0.6	0.0	0.6	0.0	1.0	3.0
Thymel.	1.0	3.4	3.2	2.3	4.7	0.9	2.3	0.7	2.7	2.6	2.6	1.0	1.8	3.0	1.6	1.4
Acanth.	1.8	1.7	0.5	1.0	0.0	0.9	0.7	0.0	1.2	0.3	1.0	1.0	1.8	0.3	0.0	0.8
Bignonia.	1.3	0.7	1.7	2.3	0.5	0.0	1.0	0.7	0.9	2.6	1.2	2.0	2.6	1.6	1.0	3.3
Rosaceae	0.0	0.7	1.0	1.2	0.0	0.6	0.7	0.0	0.6	0.6	0.3	0.0	0.0	0.3	0.0	0.0
Euphorbia.	2.0	0.0	0.2	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Malvaceae	3.0	0.2	1.0	4.0	2.9	0.0	1.0	0.7	1.2	0.0	1.0	1.0	0.2	0.3	0.0	0.4
Selagina.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.0	1.0	0.0	0.0	0.0	2.6	0.5
Gerania.	0.8	0.6	1.0	0.0	0.7	0.9	2.0	0.2	1.2	1.4	0.0	0.0	1.5	0.5	0.0	0.0
Scroph.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.7	2.0	2.0	3.5	2.2	1.6	1.2
Salicac.	0.0	0.0	0.0	4.0	5.6	45.0	11.0	20.0	5.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ranuncul.	0.0	0.0	0.0	0.0	0.0	0.0	2.3	2.6	4.6	0.0	0.0	0.6	0.0	0.0	0.0	0.0
Stercul.	2.8	1.9	1.5	0.4	2.2	1.2	1.0	1.3	1.5	0.6	0.0	0.0	1.5	2.0	0.0	0.0
Polygal.	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Polygon.	0.0	0.2	0.2	0.4	0.0	0.0	0.0	0.0	0.0	1.4	0.0	1.0	0.9	1.0	0.5	0.7
Pinaceae	0.0	0.4	0.2	0.2	0.5	0.0	0.0	0.0	0.0	0.6	0.3	4.0	0.0	0.0	0.0	0.2
Onograc.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Unknown	1.3	1.0	1.0	0.6	0.5	0.0	0.0	0.0	0.0	0.3	0.9	0.3	0.6	0.0	1.0	0.5
Spores	0.5	0.0	0.2	1.4	0.2	0.1	0.0	0.3	0.6	0.3	0.4	0.0	0.6	0.8	0.0	0.1
POLLEN SUM	397	535	404	486	448	347	298	454	327	346	344	315	340	372	189	571

4. NUWEVELDBERG: CONTEMPORARY SURFACE SAMPLE DATA - 1986.

Surface Sample	1	2	3	6	7	8	10	11	12	14	15	16
Poaceae	25.0	16.8	27.5	22.2	14.1	18.6	14.0	14.3	11.5	39.0	23.1	17.2
Cyperaceae	6.0	6.5	2.9	3.2	5.6	12.3	11.1	13.0	5.8	3.4	2.3	2.8
Iridaceae	1.5	1.4	1.2	0.9	0.0	0.6	0.6	0.3	0.5	0.0	0.9	0.8
Liliaceae	0.3	0.7	0.0	0.0	0.0	1.5	1.5	0.9	0.0	0.0	0.0	0.0
Labiatae	1.5	4.8	2.9	6.1	4.9	10.5	12.3	7.3	1.1	4.4	5.4	4.4
Asteraceae	21.0	22.0	18.6	20.2	13.2	16.7	15.2	16.4	22.7	14.6	26.0	22.4
Fabaceae	10.1	10.2	10.8	9.3	6.6	7.2	12.6	9.7	16.9	11.2	11.4	13.3
Ericaceae	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Chenopodiaceae	2.4	2.3	2.9	1.8	0.0	0.3	0.3	0.3	2.5	0.6	1.1	1.9
Mesems.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.7	0.0	2.3	0.0
Aizoaceae	0.9	1.9	0.3	0.9	0.0	0.0	0.0	0.0	3.7	0.3	1.7	4.9
Plantaginaceae	2.4	3.1	2.7	7.6	1.3	1.5	2.0	3.9	4.4	1.9	3.4	2.2
Campanulaceae	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.3	0.0	0.0	0.3	0.6
Tiliaceae	4.4	5.7	4.5	3.5	2.9	1.9	1.5	2.1	1.4	1.9	2.0	4.4
Thymelaeaceae	3.8	3.4	2.3	4.1	1.3	0.3	2.0	0.9	4.9	1.9	3.7	3.1
Acanthaceae	4.8	3.1	4.5	2.1	1.0	2.5	3.2	2.4	1.1	2.5	1.4	3.1
Bignoniaceae	2.9	7.1	5.1	4.7	0.0	4.0	4.7	4.6	5.5	4.7	6.3	6.4
Rosaceae	2.1	1.4	2.7	0.9	1.3	0.0	1.2	0.3	0.3	1.2	0.3	0.0
Euphorbiaceae	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Malvaceae	1.2	0.6	0.6	2.1	2.6	0.6	0.9	0.9	0.5	0.3	1.1	0.6
Geraniaceae	2.1	1.1	3.3	1.2	0.0	1.9	1.8	1.8	1.9	3.4	1.4	0.3
Sterculiaceae	1.5	0.6	2.1	0.0	3.3	0.0	0.0	0.0	0.3	0.0	0.0	0.0
Polygonaceae	4.0	1.9	4.2	1.8	3.3	7.7	3.8	4.6	4.7	4.9	2.0	1.4
Polygalaceae	0.0	0.3	0.6	0.3	0.3	0.0	0.0	0.6	1.4	0.3	0.3	0.0
Pinaceae	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.4	0.0	0.0	0.0
Salicaceae	0.0	0.0	0.0	3.5	36.0	3.1	3.8	6.1	0.0	0.0	0.0	0.0
Scrophulariaceae	0.0	0.0	0.0	0.6	0.0	0.0	0.0	0.0	1.1	0.0	0.3	1.7
Selaginaceae	0.9	4.8	0.0	2.3	0.7	3.1	2.9	2.7	1.4	0.6	0.9	3.3
Viscaceae	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.4	1.9
Ranunculaceae	0.0	0.0	0.0	0.0	0.0	4.0	4.9	3.6	0.5	0.6	0.0	0.8
Unknown	1.8	0.3	0.3	0.0	0.0	0.0	0.3	1.2	0.8	0.9	0.3	1.4
Spores	0.0	0.0	0.0	0.9	1.6	1.2	1.5	1.5	1.1	0.9	0.6	1.1
POLLEN SUM	339	352	335	342	304	323	342	329	365	321	350	361

4. NUWEVELDBERG: CONTEMPORARY SURFACE SAMPLE DATA - 1987.

Surface sample	1	2	3	5	7	9	10	11	12	14	15	16
Poaceae	22.0	22.0	23.0	24.0	8.4	19.0	20.0	23.0	18.0	30.0	28.0	29.0
Cyperaceae	4.5	4.2	3.0	4.0	2.3	18.0	19.0	19.0	3.1	2.0	2.0	0.3
Iridaceae	0.7	0.4	0.4	0.3	0.0	0.0	0.0	0.0	0.3	0.0	1.4	0.6
Liliaceae	0.0	0.0	0.4	0.0	0.5	2.0	0.7	1.1	0.0	0.4	0.0	0.0
Labiatae	2.7	3.0	2.6	3.0	3.3	3.4	4.7	3.6	3.4	3.5	3.0	2.1
Asteraceae	39.0	38.5	35.3	30.2	14.3	22.0	21.3	28.5	39.0	34.3	36.0	34.0
Fabaceae	9.4	9.5	11.9	9.0	7.0	9.0	9.5	7.2	13.0	10.0	00.3	12.5
Ericaceae	1.4	0.4	0.9	0.6	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0
Chenopodiaceae	2.4	2.0	1.3	2.0	0.9	0.0	0.0	0.4	2.8	0.4	0.7	3.3
Mesems.	0.7	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Aizoaceae	2.0	2.3	2.2	1.2	0.5	0.0	0.0	0.0	1.9	1.2	2.0	3.0
Plantaginaceae	2.4	1.5	1.3	3.0	0.0	0.6	2.0	1.4	0.3	2.3	1.0	0.6
Campanulaceae	0.0	0.0	0.0	0.0	0.0	2.8	1.4	0.4	0.0	0.0	0.0	0.0
Tiliaceae	1.0	0.8	2.6	0.6	0.9	1.0	0.2	0.7	1.5	1.2	1.4	2.1
Thymelaeaceae	3.7	5.3	4.3	3.7	0.0	1.2	0.7	1.1	5.2	0.8	3.0	1.2
Acanthaceae	1.7	2.0	1.4	0.9	0.0	0.0	0.2	0.0	0.0	0.4	0.7	2.4
Bignoniaceae	1.4	2.7	3.0	2.3	0.0	2.5	2.1	2.5	1.5	1.5	3.0	3.0
Rosaceae	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0
Euphorbiaceae	0.7	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Malvaceae	0.0	0.8	0.0	1.4	2.0	0.6	0.5	0.0	1.0	0.8	0.0	0.0
Geraniaceae	0.0	0.0	0.4	0.0	0.0	1.0	1.0	0.0	0.0	1.5	1.4	0.6
Sterculiaceae	3.4	2.3	2.6	3.7	0.9	1.0	2.0	1.4	0.0	1.2	1.0	4.0
Polygonaceae	2.0	1.2	0.9	0.3	0.0	0.6	0.0	0.4	1.2	1.2	0.0	0.6
Polygalaceae	0.0	0.0	0.0	0.3	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0
Pinaceae	0.0	0.0	0.4	0.3	0.0	0.0	0.0	0.0	0.0	1.2	0.0	0.0
Salicaceae	0.0	0.0	0.0	7.0	60.0	12.0	12.0	6.0	0.0	5.4	0.0	0.0
Scrophulariaceae	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Selaginaceae	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	5.0	1.2	3.4	0.6
Viscaceae	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ranunculaceae	0.0	0.0	0.0	0.0	0.0	4.7	3.3	3.2	0.0	0.0	0.0	0.0
Unknown	0.0	1.2	0.9	2.0	0.0	1.2	0.0	0.0	2.2	0.0	0.0	0.0
Spores	0.0	0.4	0.2	0.6	1.0	0.9	0.3	0.2	0.7	0.1	0.0	0.0
POLLEN SUM	296	263	231	353	215	321	428	279	324	259	292	336

5. NUWEVELDBERG: BOKKRAAL CORE 1 FOSSIL POLLEN DATA.

Depth (cm)	7	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	105	110	115	120
Poaceae	27.0	18.0	13.0	18.0	9.1	16.0	11.2	14.0	24.0	17.0	17.0	15.0	15.8	17.1	18.5	15.0	14.3	14.4	21.0	15.0	13.0	19.0
Cyperaceae	8.0	7.0	6.0	5.7	3.2	7.0	8.0	8.6	7.6	5.2	8.3	6.6	8.1	5.8	8.4	6.1	7.0	5.6	5.0	8.0	7.0	8.0
Juncaceae	1.5	1.5	1.2	1.0	0.7	0.6	2.2	0.8	0.5	1.2	1.5	2.1	0.7	1.3	1.3	1.4	1.5	1.4	1.7	1.0	0.8	1.1
Restionaceae	3.0	0.8	0.0	0.0	0.8	1.6	0.8	0.8	0.3	0.0	0.0	0.0	0.0	0.0	0.4	0.2	0.4	0.4	0.7	0.2	0.5	0.4
Aizoaceae	0.0	0.0	0.0	2.3	1.1	2.9	2.3	1.7	0.8	0.9	0.8	1.0	0.7	0.4	0.0	0.6	1.1	0.5	0.7	0.8	0.9	0.7
Campanulaceae	0.0	2.5	2.3	3.1	1.8	3.2	3.2	2.6	2.4	2.2	2.1	1.9	2.7	5.0	9.9	2.6	4.9	3.9	1.9	2.6	2.8	3.3
Caryophyllaceae	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.8	0.2	0.1	0.0
Iridaceae	0.2	1.0	2.4	2.5	0.8	1.2	2.4	1.3	1.2	1.7	0.9	1.2	1.3	1.6	1.3	2.0	3.5	1.4	2.5	2.8	2.6	2.4
Malvaceae	1.5	0.4	0.3	0.0	0.2	0.6	0.0	0.0	0.0	0.0	0.9	0.0	0.0	0.0	0.0	0.2	0.2	0.5	0.0	0.0	0.6	0.7
Plantaginaceae	0.9	0.6	0.5	3.2	3.2	2.6	2.2	2.3	2.7	2.7	3.0	4.1	4.1	4.5	2.9	5.7	4.0	3.7	3.5	4.3	4.5	3.5
Polygonaceae	0.0	1.0	0.5	1.2	0.5	1.0	1.0	0.8	1.7	1.3	0.9	1.4	0.4	0.9	0.9	0.0	0.9	1.4	0.5	0.2	0.4	0.6
Ranunculaceae	3.7	2.7	2.7	2.6	1.4	2.1	2.3	2.1	1.5	2.0	3.5	3.1	2.3	1.7	1.5	2.1	2.4	2.0	2.0	2.0	2.5	2.0
Scrophulariaceae	0.0	0.0	0.0	0.9	0.4	1.4	1.7	1.3	0.8	1.9	1.9	0.2	1.3	1.8	1.4	0.6	1.0	1.2	1.7	2.2	2.7	0.9
Viscaceae	0.0	0.0	0.0	0.3	0.6	1.3	2.3	1.9	1.7	2.3	0.9	0.9	0.7	0.9	0.9	0.9	2.2	0.7	1.3	1.8	0.3	0.9
Rosaceae	0.0	1.5	0.0	1.8	1.4	1.6	1.3	1.5	2.0	1.7	2.8	1.6	0.9	1.7	0.9	2.3	2.0	1.8	1.8	1.5	1.4	1.5
Asteraceae	13.0	18.0	18.0	10.6	10.2	15.0	15.0	15.5	15.0	12.6	13.5	15.5	17.6	12.0	10.3	17.4	9.9	14.9	8.0	12.6	16.2	13.0
Acanthaceae	3.0	3.3	6.0	2.6	1.3	3.6	5.0	2.9	3.8	2.8	3.7	3.3	2.6	2.0	1.6	1.6	2.2	1.2	1.4	1.4	1.3	1.5
Bignoniaceae	0.0	1.6	2.0	3.4	1.1	3.4	3.1	3.2	2.2	3.7	3.3	2.5	4.1	2.9	3.9	4.0	3.7	5.3	4.6	4.5	2.7	3.5
Chenopodiaceae	2.0	2.5	3.0	0.5	0.9	0.9	1.2	0.8	1.4	1.7	0.5	1.0	0.5	0.9	0.3	0.4	0.4	0.0	0.7	0.2	0.6	0.0
Crassulaceae	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.6	0.9	0.0	1.8	0.9	1.1	1.3	1.4	1.0	0.0	0.2	0.7
Ericaceae	1.5	1.5	1.5	0.9	0.7	1.6	0.8	1.2	0.7	0.7	0.6	0.3	1.0	0.2	1.0	0.8	0.4	1.2	0.7	1.3	0.2	0.9
Geraniaceae	2.0	1.0	0.9	0.2	0.7	1.0	0.2	0.8	1.4	0.3	1.0	0.9	0.7	0.0	0.3	0.8	1.1	0.4	0.5	0.3	0.5	0.4
Labiatae	3.0	4.0	2.0	3.4	1.7	3.3	3.1	4.0	1.8	3.4	4.5	3.7	5.6	4.7	2.4	4.1	6.1	4.2	4.7	4.7	3.6	3.3
Liliaceae	4.0	3.0	1.5	5.0	3.4	3.2	5.8	4.2	4.0	4.7	3.7	6.9	5.4	4.6	3.8	5.8	5.9	7.8	7.6	6.8	4.8	5.0
Papaveraceae	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.8	1.2	0.9	0.7	1.8	1.4	1.1	1.0	1.3	2.2	0.9	2.4
Apocynaceae	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.3	0.5	0.0	0.6	0.2	1.9	0.9	0.8	0.8	0.9	0.4	1.5	0.8	0.4	0.9
Polygalaceae	0.7	0.0	0.0	0.0	0.2	0.0	0.2	0.9	0.2	0.2	0.1	0.0	0.5	1.8	0.3	1.1	0.2	0.2	0.0	0.3	0.1	0.0
Sterculiaceae	6.5	3.7	4.8	1.5	1.7	3.0	2.8	2.5	2.4	2.9	3.1	2.4	3.4	3.9	3.7	3.0	2.7	4.8	3.5	3.5	2.7	3.0
Tiliaceae	1.8	1.2	1.2	1.2	0.8	0.9	1.1	0.0	0.8	1.1	0.3	0.5	0.4	0.0	0.6	0.6	0.2	0.0	0.2	0.2	0.0	0.0
Thymelaeaceae	0.7	3.9	2.6	3.9	1.2	3.3	3.2	3.0	2.5	2.1	3.4	3.1	2.5	2.8	1.3	4.0	1.5	2.8	1.5	1.2	1.8	1.7
Fabaceae	9.9	6.5	5.0	4.4	2.0	5.6	5.8	1.0	5.3	4.3	5.4	6.2	4.4	5.0	9.5	5.8	6.3	6.9	7.0	8.0	6.3	6.8
Rosaceae B	0.0	0.8	0.9	0.9	0.5	1.5	0.6	0.4	0.3	0.5	0.4	0.3	0.2	0.2	0.1	0.9	0.6	0.9	0.7	0.5	0.5	0.9
Oleaceae	0.7	0.0	0.6	0.0	0.0	0.0	0.0	0.5	0.3	0.1	0.1	0.0	0.2	0.4	0.0	0.8	0.6	0.0	0.0	1.0	0.1	0.8
Salicaceae	2.6	2.5	1.5	1.2	0.6	0.5	0.0	0.4	0.0	0.3	0.0	0.0	0.2	0.6	0.0	0.0	0.4	0.4	0.0	0.0	0.0	0.0
Unknown	4.4	5.7	4.7	5.4	3.6	4.2	4.7	4.1	3.6	4.6	5.7	6.7	5.8	4.0	4.3	5.3	5.7	4.7	5.3	5.3	3.4	4.6
Spores	5.0	3.0	3.0	3.0	1.6	0.4	3.8	3.1	0.8	3.0	1.4	3.6	1.6	2.3	1.3	1.5	0.6	1.3	3.1	1.7	2.1	1.7
POLLEN SUM	457	478	663	611	1202	747	829	993	589	1015	797	580	556	819	790	525	547	566	606	598	847	544

6. NUWEVELDBERG: BOKKRAAL CORE 2 FOSSIL POLLEN DATA.

Depth (cm)	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90
Poaceae	20.0	18.4	14.6	12.9	11.8	9.8	12.2	7.9	12.3	12.5	15.8	14.4	17.0	14.8	12.7	13.7	13.7	14.8	9.7
Cyperaceae	10.0	8.1	8.0	9.5	7.1	6.1	5.9	5.4	4.9	4.8	7.9	5.9	6.4	3.9	5.1	7.6	5.7	4.4	5.5
Juncaceae	0.8	1.8	1.7	0.6	0.9	0.3	0.4	0.3	0.3	0.2	1.1	0.6	0.7	0.6	0.6	0.5	0.4	0.5	0.9
Restionaceae	0.2	1.1	0.5	0.4	0.0	0.3	0.0	0.2	0.2	0.0	0.1	0.4	0.1	0.0	0.1	0.2	0.0	0.1	0.0
Aizoaceae	2.1	1.8	1.5	1.5	1.3	1.9	1.7	2.2	1.8	1.7	1.3	2.2	1.5	1.1	1.1	1.6	2.0	1.6	0.2
Campanulaceae	3.3	5.4	2.4	2.4	0.9	1.5	2.3	2.3	2.0	2.3	2.7	1.3	1.5	2.2	1.8	3.4	2.5	4.9	2.8
Caryophyllaceae	0.0	0.0	0.2	0.6	0.1	0.1	0.1	0.3	0.0	0.0	0.6	0.2	0.0	0.0	0.1	0.0	0.3	0.1	0.0
Iridaceae	1.5	1.9	2.4	1.9	2.0	0.9	1.6	1.7	1.4	0.7	1.4	1.6	1.0	0.8	1.2	1.7	1.9	1.6	4.1
Malvaceae	0.2	0.4	0.2	0.4	0.7	0.0	0.1	0.7	0.6	0.6	0.0	0.8	0.4	0.5	0.6	0.5	0.4	0.1	1.4
Plantaginaceae	2.5	2.1	2.9	1.9	3.6	2.6	3.7	2.6	2.8	3.1	3.2	3.2	3.0	2.9	2.9	3.7	2.9	4.3	5.3
Polygonaceae	1.4	0.0	1.2	1.3	1.5	0.9	1.0	1.5	2.0	1.7	1.5	1.6	0.7	0.5	1.1	1.7	1.9	1.2	2.3
Ranunculaceae	2.1	1.4	2.2	2.1	2.5	3.9	3.0	2.8	2.5	2.9	2.9	3.7	4.0	2.8	3.6	4.4	3.8	5.3	7.1
Scrophulariaceae	1.6	0.7	0.2	0.7	0.4	0.7	1.2	1.2	1.1	1.4	2.5	2.0	1.5	0.5	1.9	2.9	2.4	1.6	2.3
Viscaceae	0.0	1.4	4.1	0.0	1.9	1.4	1.3	2.8	1.2	2.2	2.1	1.9	1.8	0.9	1.9	2.5	1.6	1.6	1.6
Rosaceae	1.6	1.4	0.7	1.1	1.5	1.1	1.9	1.9	1.4	2.7	1.5	2.3	1.3	1.3	1.5	1.4	1.4	1.9	1.1
Asteraceae	8.2	7.7	16.0	16.9	14.0	16.5	11.0	15.0	18.4	17.0	14.2	15.3	14.4	11.9	14.4	14.0	11.7	16.5	17.7
Acanthaceae	2.3	3.0	3.4	3.1	3.3	2.6	2.5	2.6	2.8	3.8	3.2	4.0	3.2	2.4	3.6	4.7	3.7	3.6	1.4
Bignoniaceae	1.8	2.3	1.5	2.6	1.8	2.6	2.6	3.2	2.1	1.7	3.2	2.9	2.7	2.2	2.7	3.9	2.5	3.9	4.6
Chenopodiaceae	0.8	0.7	0.9	1.3	0.5	0.3	0.7	0.5	0.3	0.7	0.0	0.5	0.5	0.4	0.5	0.3	0.5	0.0	0.2
Crassulaceae	1.0	1.4	1.2	2.1	0.9	0.7	1.7	0.8	0.2	0.7	0.1	0.2	0.0	0.4	0.5	0.8	0.3	0.3	0.0
Ericaceae	1.5	1.9	1.9	1.1	0.3	0.1	0.7	0.5	0.0	0.6	1.4	0.5	0.4	0.3	0.4	0.9	0.5	0.7	0.9
Geraniaceae	0.4	1.8	1.2	1.0	1.6	0.9	0.9	1.7	0.9	1.4	1.4	0.9	1.2	0.6	0.7	1.1	1.4	0.5	0.7
Labiatae	4.7	3.2	4.1	4.2	4.4	3.7	4.8	4.8	2.8	3.2	3.8	3.2	3.0	2.8	3.2	3.9	4.2	3.6	5.5
Liliaceae	5.4	4.9	4.1	4.5	5.7	7.2	5.5	5.6	4.6	5.7	5.2	7.5	3.9	3.7	4.6	7.6	6.4	7.6	5.1
Papaveraceae	0.8	3.0	0.0	0.8	1.8	1.5	1.7	0.9	0.0	0.0	0.1	0.2	0.0	0.9	0.0	0.0	1.1	0.9	0.9
Apocynaceae	0.4	0.4	1.2	0.3	0.8	0.9	0.9	0.6	0.2	0.5	0.0	0.6	0.0	1.1	1.8	1.2	1.4	0.1	0.0
Polygalaceae	0.0	0.0	0.7	0.0	0.7	0.7	0.7	1.2	2.0	1.4	0.7	1.2	0.8	0.9	0.8	2.9	1.9	1.6	0.2
Sterculiaceae	2.7	1.1	2.9	1.9	1.8	2.6	2.3	2.8	1.5	3.5	4.4	3.7	2.9	2.0	2.9	3.3	4.0	4.3	2.1
Tiliaceae	0.0	0.2	0.5	0.3	0.7	0.4	0.5	0.2	0.0	1.0	0.4	1.3	0.6	1.1	0.8	1.6	0.8	0.6	0.7
Thymelaeaceae	1.4	0.5	0.7	2.1	1.6	2.4	2.2	0.9	1.1	1.0	1.5	1.9	1.2	0.9	2.0	1.6	2.2	2.9	3.4
Fabaceae	10.3	8.8	8.3	5.9	6.9	6.4	5.3	7.1	6.6	7.8	7.5	7.9	7.2	7.1	6.7	4.9	5.8	4.9	7.1
Rosaceae B	0.0	0.0	0.0	0.0	0.7	0.6	0.3	0.9	0.5	0.5	0.6	0.4	0.2	0.3	0.3	0.6	0.2	0.3	0.0
Oleaceae	0.0	0.0	0.0	0.1	0.5	0.4	0.4	0.5	0.5	0.4	0.2	0.2	0.0	0.5	0.3	0.0	0.2	0.5	0.0
Salicaceae	2.5	1.9	2.4	1.3	1.5	1.4	1.9	1.1	0.5	0.2	0.4	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Unknown	3.5	3.2	4.8	4.5	4.4	3.0	4.1	6.8	1.8	1.9	2.4	2.3	1.8	3.1	2.0	2.5	3.0	2.6	2.5
Spores	5.4	5.4	0.7	2.4	2.4	2.6	1.9	2.0	1.7	1.9	2.1	2.1	1.3	1.4	1.3	1.7	2.4	2.3	0.7
POLLEN SUM	485	571	411	718	757	722	1053	647	652	809	710	849	824	1125	968	641	915	675	465

7. CEDERBERG: CONTEMPORARY POLLEN TRAP DATA - 1987 & 1988.

Trap No.	3	4	1	2	10	11	7	8	5	6	12	13	14	15	16
Poaceae	1.8	3.2	3.2	10.0	0.0	3.2	11.2	11.3	3.4	4.7	12.0	11.0	5.5	18.0	22.0
Cyperaceae	9.0	7.2	9.4	17.0	4.7	1.4	0.8	4.0	10.3	18.0	6.0	7.7	9.4	2.1	1.5
Restionaceae	11.0	22.0	15.0	27.0	6.0	6.0	6.0	7.0	15.0	31.0	38.0	27.0	7.2	1.5	1.1
Rosaceae	9.0	4.8	1.1	1.2	4.7	1.6	1.2	1.5	2.8	1.0	2.1	0.0	1.7	1.0	0.0
Asteraceae	21.3	24.4	42.0	15.6	12.0	14.2	22.0	18.0	31.2	17.2	15.7	25.2	20.3	27.0	28.3
Ericeceae	3.6	4.8	4.3	2.4	53.0	58.0	8.0	5.4	3.6	4.0	5.0	5.0	6.1	3.7	5.0
Proteaceae	5.4	3.4	4.0	1.2	4.0	3.2	23.1	17.0	2.6	2.2	0.0	1.6	25.0	0.0	0.8
Iridaceae	0.9	0.0	0.0	0.3	1.2	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.8
Liliaceae	0.9	0.8	0.3	2.4	0.0	0.0	0.0	0.0	2.8	1.2	1.4	0.0	4.0	0.0	0.0
Geraniaceae	0.0	0.8	0.5	1.2	0.0	0.0	0.8	0.5	1.0	1.7	0.0	1.3	0.6	1.0	0.0
Bruniaceae	1.8	0.0	3.8	2.1	1.2	0.7	0.8	1.0	3.9	1.5	2.1	1.6	0.6	0.0	0.0
Fabaceae	13.4	8.5	6.7	6.6	3.5	3.0	5.6	4.0	7.7	3.7	7.6	7.0	6.1	15.6	14.1
Labiatae	6.3	1.1	1.6	1.8	0.0	0.9	1.2	0.0	2.1	1.5	0.7	2.6	1.1	1.0	0.4
Rubiaceae	1.8	0.3	0.5	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0
Rutaceae	1.8	1.6	0.0	0.6	0.0	0.5	0.0	1.0	1.5	0.7	0.3	2.0	2.8	0.0	0.0
Rhamnaceae	0.0	3.4	1.1	1.2	2.4	2.0	2.8	5.4	3.1	2.5	1.4	3.0	1.1	0.0	0.0
Polygalaceae	0.0	0.0	0.3	0.6	0.0	0.0	1.2	0.5	0.8	0.0	0.0	0.3	0.0	0.0	0.0
Cupressaceae	0.0	0.5	0.5	0.6	0.0	0.5	1.2	1.3	2.1	1.5	3.5	2.0	0.0	0.0	0.0
Crucifereae	2.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8
Ebenaceae	2.7	0.5	0.8	0.9	1.2	0.5	0.0	0.5	2.8	0.0	0.0	0.3	1.7	0.5	0.0
Amaranthaceae	0.0	1.1	0.5	0.6	0.0	0.0	2.8	0.3	0.0	0.5	0.7	1.3	0.0	0.0	0.0
Selaginaceae	0.0	1.6	0.0	0.0	0.0	2.0	1.2	1.3	1.0	1.5	0.0	0.0	1.7	0.0	0.0
Anacardiaceae	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.0	0.0	0.0
Ranunculaceae	0.0	0.0	0.5	0.3	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0
Pinaceae	0.0	5.4	1.3	3.3	1.2	0.7	7.2	4.6	0.0	1.2	0.3	0.0	0.0	2.6	1.5
Podocarpaceae	0.0	0.0	0.5	0.0	0.0	0.2	0.0	0.3	0.0	0.2	0.0	0.0	0.0	0.0	0.0
Aizoaceae	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.1	5.1
Chenopodiaceae	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.1	2.0
Mesems	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.3	3.3
Euphorbiaceae	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.7	2.3
Thymelaeaceae	0.9	0.5	0.5	0.6	1.2	0.9	2.0	1.0	0.5	0.5	0.3	0.0	0.0	0.5	1.5
Tiliaceae	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.6	0.8
Oxalidaceae	0.0	0.3	0.5	1.5	0.0	0.2	0.0	0.0	0.3	1.0	0.3	0.0	0.0	0.0	0.0
Crassulaceae	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.2	6.0
Campanulaceae	0.0	0.8	0.3	1.2	0.0	0.0	0.0	0.0	0.0	0.7	0.0	0.0	0.0	0.0	0.0
Unknown	6.4	2.1	0.8	0.0	3.5	1.1	1.6	1.0	0.3	0.7	1.7	0.9	0.6	0.8	1.5
POLLEN SUM	373	332	112	373	388	406	251	388	85	442	288	312	181	374	261
Spores	130	234	22	187	51	391	153	973	86	871	103	110	72	126	186

8. CEDERBERG: CONTEMPORARY SURFACE SAMPLE DATA - 1987 & 1988.

Surface Sample	2	4	6	11	12	14	16
Poaceae	9.3	9.4	7.6	10.0	9.2	8.3	14.0
Cyperaceae	13.4	19.0	7.6	22.0	8.1	4.8	4.1
Restionaceae	17.3	19.3	14.0	30.0	12.3	3.3	0.4
Rosaceae	2.7	6.7	1.3	1.8	2.0	1.5	0.4
Asteraceae	24.0	19.3	38.0	16.0	30.1	40.0	39.0
Ericeceae	5.5	2.4	6.7	3.5	5.0	3.5	2.3
Proteaceae	3.0	2.1	4.1	2.1	3.1	10.3	1.5
Iridaceae	0.0	0.3	0.0	0.0	0.0	0.0	0.0
Liliaceae	0.4	3.2	0.0	0.7	0.0	3.3	0.0
Geraniaceae	0.3	0.0	0.3	0.0	1.5	1.0	0.0
Bruniaceae	2.7	2.1	0.3	1.8	4.6	0.5	0.0
Fabaceae	4.9	6.3	5.1	3.9	6.2	11.1	15.0
Labiatae	2.5	2.4	2.5	3.2	1.9	1.8	0.8
Rubiaceae	0.0	0.0	0.3	0.0	0.0	0.0	0.0
Rutaceae	1.6	1.6	2.2	0.7	0.4	1.3	0.0
Rhamnaceae	2.2	1.9	3.2	0.7	2.7	3.3	1.1
Polygalaceae	0.3	0.3	0.0	0.7	3.8	0.0	0.0
Cupressaceae	1.1	0.0	0.0	1.0	3.5	0.0	0.0
Crucifereae	0.0	0.0	0.0	0.6	0.0	0.0	0.0
Ebenaceae	1.1	0.8	0.3	0.4	1.5	0.3	0.4
Amaranthaceae	0.5	0.3	0.0	0.7	0.0	0.0	0.0
Selaginaceae	0.5	0.0	1.0	0.0	0.0	0.5	0.0
Anacardiaceae	0.5	0.0	0.0	0.0	0.0	3.5	0.0
Ranunculaceae	0.5	0.0	0.0	0.0	0.4	0.0	0.0
Pinaceae	0.5	0.0	0.3	0.0	0.4	0.0	0.0
Podocarpaceae	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Aizoaceae	0.0	0.0	0.3	0.0	0.0	0.0	3.8
Chenopodiaceae	0.0	0.0	0.0	0.0	0.0	0.0	1.1
Mesems	0.0	0.0	0.0	0.0	0.0	0.0	0.8
Euphorbiaceae	0.0	0.0	0.0	0.0	0.0	0.0	0.8
Thymelaeaceae	2.7	0.3	1.9	0.0	1.9	0.5	1.5
Tiliaceae	0.0	0.0	0.0	0.0	0.0	0.0	1.9
Oxalidaceae	0.0	1.1	0.3	0.4	0.0	0.0	0.0
Crassulaceae	0.0	0.0	0.0	0.0	0.0	0.0	6.8
Campanulaceae	0.0	0.0	0.6	0.7	0.0	0.0	0.0
Unknown	2.0	0.5	0.9	0.7	1.5	0.3	2.3
POLLEN SUM	364	374	315	283	260	397	266
Spores	174	196	130	133	112	140	77

9. CEDERBERG: DRIEHOEK VLEI FOSSIL POLLEN DATA.

Depth (cm)	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	105	110	115	120	125	130	135	140	145	150	155
Poaceae	3.6	2.8	2.3	5.9	2.9	6.4	2.5	6.1	3.9	9.0	11.0	9.7	6.9	12.7	7.9	8.6	10.0	6.6	9.4	7.6	7.8	7.0	6.6	10.5	5.7	10.0	6.3	7.7	6.1	8.8	7.5	7.2
Cyperaceae	14.7	14.0	14.0	13.0	14.7	18.4	12.1	13.5	15.0	13.2	14.8	14.5	17.7	17.4	10.5	15.0	15.0	16.0	11.3	10.0	16.7	14.0	13.2	16.0	15.0	14.0	16.0	13.0	14.0	13.0	14.0	14.0
Restionaceae	8.6	11.0	9.4	12.7	9.4	11.7	13.0	9.5	7.3	10.0	11.2	11.5	13.5	14.6	10.5	12.4	13.0	10.0	11.9	11.4	11.2	10.0	8.4	14.0	12.0	13.0	14.0	8.3	13.5	10.0	6.1	6.8
Amaryllidaceae	1.0	0.6	0.0	0.6	0.0	0.3	0.0	0.7	2.1	0.6	0.7	0.0	0.0	0.4	2.0	2.0	0.8	1.3	1.4	4.0	1.7	1.6	0.0	1.6	0.8	2.1	1.0	0.8	1.6	1.4	0.0	0.0
Fumariaceae	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.5	0.6	0.0	0.0	0.0	0.0	0.0	0.6	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.3	0.0
Juncaceae	0.5	0.6	0.9	0.6	1.2	0.6	1.4	0.0	0.9	0.0	0.0	0.5	0.5	0.3	0.0	0.1	0.5	0.9	0.0	0.0	0.0	0.0	0.5	0.4	0.4	0.3	0.0	0.6	0.0	0.0	0.0	0.0
Labiatae	2.4	1.2	2.8	2.1	2.9	1.1	1.9	2.9	1.8	2.9	1.3	2.3	4.1	3.7	3.0	1.3	3.5	3.8	2.8	4.0	3.4	3.6	2.5	3.8	2.8	3.2	4.2	3.7	3.6	3.4	3.5	3.9
Liliaceae	3.9	3.9	2.3	2.9	3.6	2.5	0.9	0.7	0.5	0.3	0.0	0.5	0.0	1.3	0.4	1.0	1.3	3.0	1.8	1.0	1.1	1.1	1.1	1.6	1.0	1.5	0.7	1.0	1.2	1.7	0.9	0.3
Oxalidaceae	0.0	0.3	0.8	0.0	0.6	0.6	0.0	0.7	0.0	0.3	0.6	0.0	0.0	1.3	0.0	0.5	0.0	0.4	0.5	1.0	0.4	0.3	0.0	1.2	0.0	0.0	0.8	0.0	0.4	0.7	0.0	0.0
Ranunculaceae	0.0	0.9	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.9	0.0	0.0	0.8	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.3	0.0
Aizoaceae	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.4	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Asteraceae	14.0	21.0	19.0	17.0	20.0	20.0	21.3	22.4	20.0	16.2	20.7	21.0	18.3	17.5	19.9	15.7	14.3	23.1	19.0	17.3	18.3	17.8	19.0	17.4	17.6	17.8	18.7	21.0	17.6	17.4	17.1	20.1
Bruniaceae	1.0	1.5	0.0	1.2	0.6	0.3	0.0	0.0	1.2	1.0	1.5	0.9	0.9	1.3	1.1	0.5	0.5	0.4	0.0	0.0	0.0	0.7	0.8	0.4	1.6	0.6	0.3	1.0	0.8	1.7	1.2	0.8
Campanulaceae	0.0	0.6	0.8	0.4	0.0	0.4	1.9	0.3	1.2	0.6	0.7	1.4	0.5	0.8	1.6	1.0	0.8	1.3	0.0	0.0	0.0	0.3	0.8	0.4	1.2	0.6	0.3	0.0	2.4	1.7	0.9	1.3
Caryophyllaceae	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.4	0.0	0.0	0.0	0.2	0.7	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0
Crucifereae	0.0	0.0	1.5	0.3	1.1	0.4	0.0	0.0	0.5	1.0	0.7	0.5	0.0	1.1	0.0	0.0	0.8	1.3	0.5	1.0	0.4	0.7	0.3	0.4	1.2	0.0	0.0	1.3	0.3	1.0	0.3	0.2
Ericaceae	2.7	4.4	4.0	3.7	4.2	4.7	8.1	4.7	5.7	5.7	4.4	2.5	5.9	4.2	5.6	6.3	7.0	3.6	6.9	3.7	3.0	5.7	3.5	3.2	3.8	4.2	3.1	4.3	4.0	4.2	6.0	5.5
Fabaceae	5.1	5.0	4.5	3.5	5.8	5.0	5.2	4.9	7.1	5.4	6.5	7.8	4.1	4.7	5.6	5.0	5.1	3.3	5.6	3.5	5.5	5.2	4.4	6.2	2.9	4.8	2.9	4.2	6.0	4.8	3.5	6.1
Geraniaceae	0.5	0.0	1.1	0.8	0.9	0.8	0.5	1.5	2.7	0.0	0.7	0.5	0.9	0.0	0.4	1.5	0.3	0.0	0.0	0.5	0.4	0.0	0.3	0.4	0.4	1.5	0.3	0.0	0.0	0.3	0.3	0.6
Iridaceae	1.4	1.2	0.8	1.5	1.6	0.9	0.0	1.7	0.9	1.3	1.5	0.5	1.5	0.0	0.8	0.2	0.5	0.4	0.0	2.0	0.0	0.7	0.3	0.4	0.0	0.3	0.7	1.0	1.2	0.3	0.3	0.0
Malvaceae	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.7	0.5	0.0	0.0	0.6	0.6	0.0	0.4	0.0	0.0	0.0
Proteaceae	5.3	1.9	6.4	4.4	3.9	2.8	5.7	5.8	3.5	1.6	3.0	0.9	1.9	2.3	2.8	3.7	1.9	1.8	4.0	4.0	2.5	3.9	2.7	4.4	2.6	3.3	2.2	3.5	3.2	2.2	4.1	1.6
Polygalaceae	1.2	0.3	1.5	1.9	0.9	0.9	0.5	0.0	0.9	1.0	0.4	0.9	0.9	0.0	0.0	1.5	0.3	0.4	1.1	1.0	1.3	0.7	1.6	0.0	1.8	0.0	1.0	2.3	0.4	0.7	1.2	1.9
Rosaceae	4.3	5.0	4.1	4.3	3.7	3.1	2.8	4.1	0.9	2.5	2.9	2.5	1.5	1.7	3.6	2.5	3.0	2.9	2.1	3.5	3.4	1.9	5.5	2.4	2.0	2.1	3.1	2.9	1.2	1.4	2.2	3.2
Rhamnaceae	3.9	1.9	2.1	2.6	3.6	1.5	3.8	3.4	4.0	2.7	1.8	2.1	3.4	2.3	4.6	2.0	2.1	1.3	2.3	2.5	2.1	2.3	2.4	1.9	3.9	3.0	2.4	2.3	1.2	1.4	2.2	3.1
Rubiaceae	0.5	0.3	0.4	0.3	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.3	0.4	0.0	0.0	0.4	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.0	0.0
Rutaceae	2.4	2.3	1.3	2.9	2.9	2.3	2.4	1.7	1.8	1.9	0.7	1.2	1.5	1.3	2.5	1.4	1.1	1.3	1.8	1.5	0.0	1.6	1.0	0.8	1.6	0.9	1.6	1.9	0.8	1.0	1.2	0.9
Santalaceae	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.4	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.9	0.0	0.0	0.7
Scrophulariaceae	1.9	1.2	1.1	0.4	1.8	1.4	0.7	0.0	2.1	0.6	0.4	2.1	1.5	0.8	1.0	1.0	1.3	0.0	0.9	0.0	2.0	1.5	1.1	1.9	1.4	0.9	0.7	1.6	1.6	0.7	1.8	1.9
Sterculiaceae	1.4	1.4	1.9	0.0	0.7	0.6	0.9	0.7	0.5	1.0	0.0	0.9	0.9	1.1	1.2	0.2	0.3	0.5	0.9	0.5	1.4	0.7	1.4	0.8	1.4	0.9	1.0	1.3	0.8	0.3	1.2	0.8
Thymelaeaceae	1.0	1.5	2.3	3.2	2.8	1.9	2.1	3.0	2.3	1.9	1.8	0.9	1.9	1.3	1.2	2.0	2.7	2.5	1.4	2.0	2.5	2.3	1.4	1.6	0.4	1.5	1.2	1.3	0.4	1.4	1.5	0.6
Myricaceae	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.4	0.3	0.3	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.2	0.0
Pinaceae	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cupressaceae	0.5	0.3	0.0	0.6	0.0	0.7	0.7	1.0	1.0	1.6	2.2	0.9	1.9	0.8	1.6	1.5	1.2	1.3	1.4	3.5	2.1	3.0	2.0	1.9	3.0	3.4	2.6	2.7	0.4	3.4	3.4	3.2
Unknowns	3.6	1.6	2.1	2.1	3.2	2.8	3.2	8.0	7.7	4.2	3.7	3.0	6.1	4.8	4.6	2.6	2.1	2.6	3.3	2.9	3.0	3.0	3.2	2.2	4.5	3.2	4.2	2.0	3.1	3.8	4.1	2.7
Spores	14.9	13.4	11.1	10.2	6.7	7.6	6.6	8.0	7.7	13.5	6.7	12.2	6.1	4.8	6.4	8.7	9.3	10.5	7.5	11.2	9.5	9.2	14.7	10.3	10.5	6.4	8.0	11.1	12.4	12.3	13.8	12.8
POLLEN SUM	415	646	532	678	674	720	423	591	878	629	541	433	812	943	1004	1625	752	940	870	792	955	1232	1466	1032	1030	1333	1180	1245	990	1163	1367	1269

DRIEHOEK FOSSIL POLLEN DATA CONTINUED.

Depth	160	165	170	175	180	185	190	195	200	205	210	215	220	225	230	235	240	254	250	255	260	265	270	275	280	320	325	330	335	340	345	350	355
Poaceae	4.0	6.7	6.1	5.0	3.6	5.8	7.8	6.9	4.4	4.8	7.5	7.5	8.5	6.7	7.6	6.3	7.9	3.8	9.4	7.2	7.0	4.5	7.0	6.4	9.2	6.9	10.0	6.4	11.0	11.0	6.2	6.1	8.4
Cyper.	13.0	12.0	11.0	11.7	14.3	10.8	13.0	10.7	12.0	10.5	17.0	11.3	13.0	8.6	12.6	14.0	16.7	10.0	14.0	11.2	13.0	12.0	10.0	13.0	13.0	17.0	13.0	14.0	19.0	14.0	14.4	12.0	15.0
Restio.	10.3	8.8	8.3	7.0	10.5	10.9	11.8	15.0	8.5	8.7	9.5	9.6	8.5	11.0	14.6	8.8	10.0	8.3	9.0	8.9	9.0	9.3	14.0	15.0	12.5	14.0	12.0	8.3	11.0	16.0	10.0	13.0	11.0
Amaryll.	0.3	0.0	1.4	0.3	0.0	0.4	0.6	0.0	0.3	1.5	1.1	1.0	1.4	2.0	1.0	1.0	0.4	0.8	0.4	0.0	1.8	1.7	0.4	0.0	0.0	0.3	0.0	1.1	0.6	0.4	1.2	0.0	0.0
Fumaria.	0.3	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.6	0.0	0.3	0.0	0.0	0.0	0.0	0.3	0.0	0.0	3.0	0.0	0.0	0.0	0.0
Juncac.	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Labiat.	3.6	3.5	4.1	4.7	1.5	5.2	5.0	4.8	3.9	4.5	5.0	4.8	5.0	5.6	2.8	3.9	4.2	3.8	4.1	3.8	3.4	4.0	3.8	4.0	4.0	3.7	3.6	4.0	4.1	5.0	3.3	2.7	3.1
Lilia.	1.0	0.7	0.3	1.0	1.0	1.2	0.9	0.4	0.5	0.0	0.5	2.0	2.4	0.7	0.0	0.3	0.0	0.8	0.4	1.4	0.3	1.1	0.9	2.0	0.5	0.9	0.7	1.0	0.6	0.9	1.2	1.2	0.4
Oxalid.	0.0	0.7	0.0	0.0	0.5	0.4	0.6	0.0	0.0	0.0	0.5	1.4	0.0	1.1	0.4	0.3	0.4	0.0	0.0	0.4	0.0	0.0	0.6	0.6	0.2	0.0	0.2	0.0	0.6	0.4	0.4	0.0	0.0
Ranun.	0.0	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.5	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Aizoac.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.5	0.0	0.0	0.0	0.4	0.0	0.5	0.0	0.0	0.3	0.0	0.0	0.0
Aster.	22.0	17.2	24.3	23.9	24.4	17.5	12.7	17.4	18.4	21.5	20.1	16.7	21.3	23.7	17.4	21.2	13.6	35.5	19.6	19.6	14.4	21.2	20.6	14.2	18.5	18.3	14.7	17.7	27.4	20.3	22.0	18.7	17.6
Brunia.	1.5	0.7	0.3	2.5	1.1	0.4	0.0	1.1	1.5	0.0	1.1	1.4	0.5	0.0	0.4	0.0	0.0	0.0	0.4	0.8	1.5	0.0	0.9	0.4	0.2	0.6	0.2	0.6	0.6	0.0	0.0	0.5	0.0
Campan.	0.3	1.1	0.3	0.0	0.5	0.4	0.0	0.5	0.5	0.0	0.0	0.0	0.0	0.4	1.2	0.3	0.8	0.0	0.4	1.4	1.2	0.6	0.9	0.9	1.4	1.1	1.2	0.8	2.2	0.9	0.8	0.5	0.4
Caryoph.	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Crucif.	2.0	0.7	0.3	0.5	0.5	1.2	0.9	0.0	0.3	0.4	1.1	0.0	1.1	0.0	0.4	0.3	0.8	0.8	0.0	0.0	0.9	0.0	0.9	0.3	0.4	0.0	0.2	0.8	0.0	0.0	0.4	0.0	1.8
Erica.	5.0	4.6	2.2	4.2	3.8	4.7	5.5	3.8	3.2	4.7	3.7	6.3	4.3	2.2	2.8	2.4	5.7	3.0	2.3	2.4	11.0	1.3	2.6	2.5	2.6	2.6	3.2	2.7	1.9	5.6	2.1	1.1	2.6
Fabac.	3.5	5.8	4.1	4.2	6.8	5.0	5.5	3.8	4.4	3.4	5.0	4.7	4.3	5.7	5.3	5.8	5.4	6.8	7.0	5.0	5.0	6.9	4.7	4.5	5.0	4.3	4.0	4.3	10.0	5.2	5.3	5.9	4.4
Gerania.	0.3	0.7	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.4	0.0	1.0	0.0	0.0	0.0	0.7	0.0	0.0	0.4	0.0	0.0	0.0	0.4	0.0	0.2	0.0	0.0	0.0	0.0	0.9	0.0	0.0	0.0
Iridac.	0.3	0.7	1.4	0.3	0.0	0.4	0.3	0.0	1.3	0.4	0.5	0.5	0.5	1.5	1.6	1.0	1.7	0.8	1.1	0.5	0.8	1.1	1.3	0.6	0.7	0.3	0.2	0.8	0.6	0.0	0.0	0.5	0.4
Malva.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Protea.	4.0	2.8	3.4	1.3	1.5	1.5	1.7	4.3	0.8	2.8	0.9	3.5	4.3	2.6	2.4	2.4	1.7	3.0	3.2	0.0	3.0	5.1	1.3	1.3	3.1	1.4	4.2	2.7	6.0	4.0	3.1	4.8	4.0
Polygal.	1.2	1.1	0.0	1.2	0.5	0.0	0.6	0.5	2.0	0.0	0.0	0.0	0.0	0.7	0.0	0.0	0.8	0.0	0.0	0.0	0.0	0.0	0.4	0.9	1.1	0.9	0.5	0.3	0.0	0.4	0.4	0.5	0.9
Rosac.	2.6	2.0	1.0	1.3	3.6	0.4	2.1	1.1	3.7	0.0	1.6	0.5	0.0	0.7	0.8	0.3	0.8	0.8	1.1	0.0	0.9	0.6	1.8	1.7	2.0	2.3	1.7	2.0	2.5	0.9	0.4	0.5	0.9
Rhamna.	0.3	1.8	2.2	1.7	0.5	2.7	2.5	4.3	2.0	2.4	1.6	2.9	0.5	2.6	2.4	2.4	1.3	2.3	2.3	1.9	2.7	1.7	1.3	3.0	3.0	2.3	1.8	2.0	2.5	2.2	1.6	2.7	2.2
Rubia.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.0	1.4	1.2	0.9	0.4	1.3	0.0
Rutac.	1.0	2.3	0.7	1.5	1.8	1.2	3.8	1.1	1.5	2.4	2.1	1.4	1.3	1.8	1.2	1.7	2.9	2.3	2.3	1.4	1.8	3.4	2.6	2.0	2.0	2.6	1.6	1.6	3.7	1.8	1.6	0.0	0.8
Santal.	0.3	0.0	0.9	0.7	0.0	0.8	0.0	2.1	0.8	1.9	0.0	1.4	1.7	1.2	1.4	1.0	1.3	0.8	2.6	0.0	0.0	0.0	0.0	0.6	0.2	1.1	0.7	0.8	2.0	0.4	1.4	0.8	1.8
Scroph.	1.4	1.2	2.6	0.0	0.5	0.8	1.5	1.6	1.1	1.5	1.1	1.2	0.0	0.4	1.2	0.9	0.8	0.0	2.0	1.9	0.8	1.7	1.8	0.6	0.8	1.4	2.0	1.6	1.9	0.4	2.3	1.1	1.8
Stercul.	1.2	1.1	0.3	0.0	1.5	0.0	0.6	0.5	1.3	0.0	0.4	0.0	0.0	0.7	1.2	0.3	0.4	0.8	0.8	1.4	1.1	0.6	0.4	0.9	0.7	0.6	1.6	0.8	0.6	1.8	0.0	0.6	0.4
Thymel.	2.2	0.7	0.7	1.7	0.0	1.9	0.8	0.0	1.8	1.7	1.6	1.4	1.4	1.8	2.6	0.3	0.4	1.5	0.8	1.5	0.6	1.7	1.8	2.0	1.2	0.6	1.5	1.6	3.1	3.1	0.4	1.1	0.4
Myric.	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pinac.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cupres.	3.8	5.2	4.5	4.4	5.0	5.0	5.1	4.0	3.9	4.8	4.0	3.4	5.2	3.6	4.7	5.1	4.0	4.5	4.3	6.5	5.6	6.0	5.6	6.0	5.2	6.0	7.0	4.8	9.2	7.1	6.4	6.9	6.6
Unknown	4.4	4.7	4.5	4.3	4.8	5.8	4.5	8.1	6.1	4.7	2.8	6.3	3.8	4.4	5.6	6.1	5.8	3.2	3.9	6.6	4.9	7.5	4.2	4.3	4.8	3.7	4.8	6.5	6.5	6.0	4.5	4.9	4.9
Spores	10.8	11.8	13.5	13.7	11.5	15.6	12.6	12.4	14.1	16.1	11.1	9.3	11.6	10.3	8.4	12.8	11.7	7.6	7.8	10.8	11.6	9.9	8.8	8.4	8.4	10.3	9.3	10.5	15.4	11.8	10.7	12.0	9.6
SUM	1385	1132	1160	1195	784	1039	1306	749	1581	1073	761	831	847	1098	1012	1169	958	533	1064	833	1315	706	914	1275	1683	1394	1649	1473	641	896	970	751	908

DRIEHOEK FOSSIL POLLEN DATA CONTINUED.

Depth	360	365	370	375	380	385	390	395	400	405	410	415	420	425	430	435	440	445	450	455	460	465	470	475	480	485	490	495	500	505	510	515	520
Poaceae	9.6	10.0	9.7	10.0	8.3	7.9	7.6	9.7	10.1	8.0	6.0	8.3	7.9	9.6	9.7	8.3	9.4	12.0	11.0	8.1	10.0	8.9	8.6	7.3	8.1	7.6	6.1	9.4	7.9	7.0	8.7	7.4	7.2
Cyper.	14.0	17.0	7.3	17.0	16.0	13.0	14.3	12.2	13.0	13.0	10.3	12.0	9.6	14.0	16.0	12.0	13.0	15.0	15.0	15.0	14.0	13.0	12.0	16.0	9.1	11.0	11.0	16.0	12.0	9.0	13.0	13.0	14.3
Restio.	9.4	10.6	11.1	10.8	11.0	12.0	11.0	11.3	12.0	7.1	6.7	8.6	8.1	11.2	11.0	12.1	10.0	11.3	12.4	11.0	13.0	10.0	9.2	15.0	11.1	9.8	10.0	13.0	14.0	7.2	10.6	11.0	9.3
Amaryll.	0.3	0.4	0.7	0.7	0.0	0.8	0.6	0.5	0.4	0.3	0.8	1.0	0.0	0.7	0.8	0.3	0.6	0.0	0.3	0.0	1.0	0.0	0.3	0.5	0.0	0.6	0.5	0.3	0.6	0.7	0.2	0.4	1.2
Fumaria.	0.0	0.0	0.0	0.0	0.3	0.2	0.3	0.0	0.0	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.4	0.5	0.0
Juncac.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.3	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0
Labiat.	3.2	3.6	3.3	4.5	4.5	4.2	3.0	4.2	4.6	3.9	6.2	6.2	4.2	4.3	3.5	4.6	3.7	2.9	3.3	4.1	4.2	4.2	2.9	4.6	4.2	3.9	5.2	3.6	6.0	4.3	3.6	3.7	5.1
Lilia.	1.4	0.4	0.7	0.7	0.7	0.3	1.5	0.3	0.7	0.5	0.0	0.6	0.3	0.7	0.6	0.0	1.2	0.8	0.9	0.2	0.5	0.6	0.6	0.5	0.8	0.6	0.7	0.3	0.4	1.0	0.6	1.1	1.3
Oxalid.	0.0	0.4	0.0	0.7	0.7	0.3	0.0	0.0	0.0	0.0	0.3	0.7	0.3	0.0	0.3	0.3	0.0	0.4	0.3	0.0	0.6	0.0	0.0	0.5	0.4	0.6	0.7	0.0	0.0	0.2	0.2	0.1	0.0
Ranun.	0.6	0.0	0.0	0.0	0.0	0.5	0.0	0.3	0.0	0.0	0.0	0.0	0.3	0.2	0.0	0.3	0.2	0.0	0.0	1.4	0.0	0.0	0.3	0.0	0.4	0.8	0.7	0.0	0.0	0.6	0.4	0.2	0.6
Aizoac.	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Aster.	16.0	14.2	18.0	15.1	10.6	15.4	14.3	15.3	19.1	16.6	18.3	20.5	16.7	22.7	17.4	18.9	14.6	16.8	17.0	19.8	19.0	18.2	15.3	11.1	19.8	17.0	15.3	14.1	13.1	19.0	16.4	14.2	13.8
Brunia.	0.9	0.9	0.4	1.0	0.7	0.5	1.5	0.5	0.0	1.6	0.8	0.3	1.8	0.0	0.6	0.0	1.2	1.5	0.9	0.0	2.5	1.2	2.1	1.7	0.0	1.4	1.1	0.3	0.0	0.8	1.9	1.8	1.3
Campan	1.4	0.0	1.5	0.0	1.0	1.4	1.2	0.5	0.0	0.5	0.3	1.2	0.3	0.3	0.0	1.1	0.3	0.4	1.2	1.8	1.0	1.5	1.5	1.5	1.6	0.8	1.5	1.6	0.9	0.7	1.4	0.4	0.6
Caryoph	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0
Crucif.	1.4	0.4	0.4	0.0	1.0	0.8	0.3	1.1	1.2	0.3	0.8	0.6	0.7	0.0	0.3	0.6	0.6	0.0	0.3	0.0	0.6	0.3	0.9	0.0	0.0	0.3	0.0	0.3	0.0	0.2	0.0	0.0	0.0
Erica.	2.3	3.1	3.7	2.4	2.4	2.6	1.8	3.3	2.1	3.3	3.5	3.4	2.9	2.7	2.5	2.6	3.7	3.4	4.8	3.2	2.5	2.2	2.5	3.4	1.2	3.0	1.5	1.0	3.0	3.0	2.4	4.1	3.6
Fabac.	5.2	2.7	5.6	5.5	6.2	3.4	6.1	5.6	6.0	5.9	5.5	6.2	6.3	6.3	5.6	4.3	5.3	5.2	4.5	4.5	4.4	3.0	5.0	7.3	5.6	4.3	5.2	6.0	5.0	5.0	3.8	4.8	4.8
Gerania.	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.4	0.2	0.6	0.3	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	1.5	0.6	0.3	0.5	0.0	0.3	0.0	0.3	0.0	0.0	0.2	0.4	0.6
Iridac.	0.6	0.0	1.1	0.0	0.7	0.8	0.0	0.3	0.0	0.5	0.3	0.3	1.0	0.0	0.0	0.6	0.6	1.1	0.3	0.5	0.5	0.6	1.5	0.5	0.4	0.3	0.0	0.3	0.0	0.4	1.0	0.6	0.5
Malva.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0
Protea.	2.0	4.0	2.6	2.1	2.1	1.8	2.7	2.9	2.1	0.8	3.3	2.1	3.4	2.1	1.7	2.3	3.7	1.5	3.0	3.7	3.4	3.2	3.6	1.9	2.4	3.2	5.0	2.3	2.7	2.0	1.6	3.0	4.7
Polygal.	0.6	0.4	0.4	0.3	0.3	0.6	0.9	0.5	0.0	0.0	1.5	0.0	1.0	1.4	0.0	0.0	0.3	0.8	0.0	0.5	0.0	0.6	0.3	0.0	0.0	0.8	0.7	0.0	0.6	0.3	0.6	0.7	1.0
Rosac.	0.0	1.3	0.7	1.0	3.1	1.6	1.8	2.7	4.3	2.4	3.0	1.8	2.0	2.8	1.7	2.6	2.2	1.5	1.5	0.9	1.5	1.5	2.5	1.0	1.2	1.7	0.7	1.6	2.6	2.2	2.4	1.8	1.0
Rhamna.	2.3	1.3	1.7	2.8	3.5	2.6	2.6	3.0	1.4	2.1	2.5	2.4	3.4	1.9	2.8	1.7	3.1	1.1	1.7	2.3	1.5	2.7	2.7	2.0	2.4	3.0	2.6	2.8	1.7	2.2	2.4	1.5	2.2
Rubia.	0.3	0.4	0.0	0.0	0.3	0.9	0.3	0.8	1.1	0.3	0.8	0.0	0.0	0.0	0.6	0.6	0.3	0.0	0.0	0.0	0.5	0.0	0.3	0.0	0.0	0.0	0.7	0.3	1.3	1.3	1.4	0.9	1.7
Rutac.	2.0	0.9	1.9	1.7	1.4	2.6	2.6	1.3	1.1	1.8	3.1	1.3	1.2	1.4	2.3	2.4	1.2	1.9	1.5	1.4	1.0	1.5	2.1	1.5	2.0	2.2	1.5	1.6	1.7	1.3	1.1	2.0	1.0
Santal.	1.1	2.2	0.4	1.0	0.9	0.3	1.2	0.3	0.9	0.5	0.8	0.0	0.0	0.0	1.0	0.9	0.3	0.8	0.0	0.9	0.0	1.2	1.5	1.1	1.6	0.3	0.4	0.3	0.4	0.7	1.1	0.9	1.3
Scroph.	2.2	1.3	0.7	1.4	0.7	1.4	1.4	0.5	1.4	0.3	1.4	1.2	2.7	0.7	0.8	1.6	0.9	0.8	1.2	0.5	1.7	1.5	0.9	1.2	1.3	0.8	1.2	0.3	1.3	0.2	1.2	1.2	1.0
Stercul.	1.4	0.4	0.6	0.7	0.0	1.6	0.0	0.0	0.4	1.3	0.3	0.9	0.7	0.3	0.6	0.9	1.2	1.1	1.2	0.0	1.0	0.9	0.9	0.5	0.8	1.4	1.5	1.0	1.3	1.8	0.4	0.7	1.3
Thymel.	0.6	1.8	1.1	1.0	0.7	0.3	0.6	0.5	0.0	0.5	0.3	0.0	0.3	0.3	0.3	1.2	0.3	0.0	1.5	0.5	0.0	0.6	0.6	0.0	0.8	1.2	0.0	0.3	0.9	1.8	1.4	0.7	0.3
Myric.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sinac.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cupress.	6.6	7.9	9.0	6.1	7.0	5.3	7.1	6.3	5.8	6.6	5.0	5.1	6.7	4.5	5.6	6.4	8.2	6.8	7.3	8.6	8.6	8.2	7.9	8.8	9.0	7.0	9.8	10.2	6.7	7.0	7.2	7.8	8.3
Unknown	4.3	4.9	4.7	3.9	4.9	5.1	6.7	6.3	3.9	4.2	6.1	5.8	4.7	3.2	4.8	5.4	4.8	4.7	4.2	3.7	5.7	4.3	2.9	2.6	3.8	4.5	3.4	3.7	5.0	5.4	4.4	4.2	4.6
Spores	13.7	8.3	10.1	9.9	11.2	11.8	8.5	9.6	8.4	13.4	11.2	8.6	14.4	7.3	9.0	8.2	10.9	9.0	6.3	7.3	6.7	9.1	11.4	9.0	12.1	11.9	12.9	8.2	9.9	14.4	9.8	10.8	7.2
SUM	1389	889	1077	1150	1157	1518	1320	1504	1129	1523	1442	1345	1192	1165	1440	1395	1283	1046	1322	887	816	1337	1347	819	1012	1454	1081	1236	931	1819	2009	2268	1263

10. CEDERBERG: SNEEUBERG VLEI FOSSIL POLLEN DATA.

epth (cm)	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	105	110	115	120	125	130	135	140	145	150
oaceae	12.0	15.3	12.0	11.7	11.3	7.9	11.5	11.5	10.0	17.5	8.4	8.2	15.5	9.0	10.0	13.0	10.0	10.0	14.0	14.0	12.0	9.0	14.0	10.0	10.3	15.0	12.0	12.0	11.0	13.0	13.0
yperaceae	9.0	3.7	6.9	7.8	8.1	9.3	11.0	11.0	9.6	17.0	11.0	9.1	11.0	7.0	9.0	8.2	7.5	8.0	8.0	9.0	7.1	6.0	7.3	7.5	7.4	6.3	8.0	7.5	7.4	6.4	6.9
estionaceae	30.0	22.0	23.0	19.0	20.0	18.0	16.0	17.0	16.0	12.0	14.0	13.0	18.0	15.0	23.0	20.0	20.0	17.0	14.0	15.0	16.0	17.0	14.0	13.0	18.0	15.0	17.0	18.5	15.0	19.0	17.0
maryllidaceae	3.0	2.0	2.5	1.8	1.6	1.7	0.7	1.4	0.8	0.1	0.1	0.6	0.6	0.2	0.3	0.8	1.1	0.5	0.8	1.0	0.9	0.3	0.7	0.5	0.6	1.0	0.4	1.0	0.9	1.1	0.0
umariaceae	0.0	0.3	0.2	0.4	0.9	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	1.0	0.0	0.1	0.6	0.5	0.2	0.0	0.6	0.0	0.2	0.4	0.4	0.7	0.4
uncaceae	0.4	0.2	0.1	0.5	0.5	0.2	1.8	2.0	0.4	0.5	0.1	0.6	0.5	0.6	0.6	1.0	0.3	0.3	0.4	0.3	0.9	1.0	0.0	2.0	0.6	1.3	0.9	0.8	0.9	0.5	0.9
abiatae	0.0	1.2	2.4	1.4	2.0	1.6	1.2	2.0	2.0	1.0	0.9	1.5	1.4	2.1	0.5	2.0	1.4	2.0	1.2	2.0	2.0	2.5	2.0	2.0	2.0	0.8	1.8	1.4	1.6	1.8	0.9
iliaceae	1.0	1.2	2.2	1.4	2.5	1.4	1.4	0.4	0.5	0.5	0.7	0.0	0.6	0.4	0.3	0.6	0.2	0.5	0.9	0.4	0.6	0.9	0.2	0.3	0.3	0.8	0.4	0.5	0.4	1.1	0.6
xalidaceae	0.0	0.7	0.0	0.2	0.2	0.2	0.0	0.4	0.4	0.2	0.5	0.0	0.5	0.0	0.0	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0	0.0	0.0	0.4	0.0	0.0
anunculaceae	0.5	0.0	0.2	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
izoaceae	0.5	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
mbellifereae	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.4	0.3	0.5	0.3	0.0	0.0	0.0	0.0	0.0	0.3	0.8	0.0	0.1	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
steraceae	8.3	12.0	12.0	11.8	14.4	17.0	15.0	12.0	12.0	12.0	13.0	22.0	15.0	16.0	21.0	21.0	16.0	12.6	17.5	16.0	16.0	14.0	15.0	19.0	18.0	20.0	15.0	18.0	14.0	14.0	12.4
runiaceae	1.1	0.4	0.6	2.2	1.8	2.5	2.2	3.2	1.0	1.3	1.2	2.0	1.0	2.0	3.0	0.6	2.3	1.0	1.5	2.0	1.2	1.0	1.5	1.3	1.5	1.6	1.4	0.6	0.9	1.3	1.1
ampanulaceae	0.7	1.2	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.3	0.2	0.8	1.2
aryophyllaceae	0.7	0.7	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
rucifereae	0.8	1.2	0.5	0.3	0.0	0.0	0.2	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0
ricaceae	5.5	4.0	3.1	6.7	4.5	8.5	6.0	8.2	7.7	6.6	11.0	7.3	8.5	8.0	4.8	8.0	5.4	7.0	7.4	6.3	4.6	6.5	7.5	8.0	6.0	5.3	7.0	7.0	9.0	9.4	10.0
abaceae	5.0	4.6	4.0	4.0	5.0	4.0	4.2	5.0	4.2	4.8	3.3	4.0	5.0	4.0	4.0	6.0	4.5	5.0	3.4	5.1	5.9	4.5	4.0	4.3	4.0	4.0	3.3	3.6	3.8	5.0	4.3
eraniaceae	0.5	0.2	0.3	0.2	0.2	0.0	0.4	0.5	0.5	0.0	0.3	0.3	0.5	0.4	0.0	0.0	0.0	0.7	0.4	0.3	0.5	0.0	0.4	0.0	0.3	0.0	0.3	0.0	0.4	0.0	0.0
ridaceae	0.9	0.7	4.3	1.1	1.2	0.8	2.0	1.6	2.0	0.2	1.3	0.5	1.2	0.6	0.3	0.4	0.8	1.3	1.0	1.3	1.7	1.3	0.6	0.5	0.9	2.2	1.0	1.2	1.1	0.9	0.9
alvaceae	0.0	0.0	0.2	0.2	0.4	0.3	0.2	0.2	3.0	0.0	0.1	0.2	0.0	0.0	0.0	0.0	0.0	0.2	0.1	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ontiniaceae	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0
olygalaceae	1.4	1.0	0.7	0.7	0.4	0.5	0.5	0.2	0.0	0.8	0.3	0.6	0.2	0.0	0.0	0.4	0.2	0.2	0.1	0.5	0.7	0.5	0.9	0.0	0.6	0.7	0.8	0.0	0.9	0.5	0.2
roteaceae	0.6	1.2	0.6	0.1	0.9	0.0	3.4	2.8	5.0	3.2	2.0	6.6	2.2	7.0	5.4	6.0	5.1	5.0	5.2	6.5	5.2	7.0	4.0	6.0	7.0	6.6	4.0	4.2	5.0	0.5	3.9
osaceae	0.9	0.8	1.3	1.4	1.2	1.4	2.6	2.7	3.2	2.0	1.3	2.7	0.9	3.6	3.0	3.0	3.5	2.3	1.5	1.5	2.0	2.6	2.4	1.3	2.0	2.0	1.5	1.1	2.3	0.8	2.0
hamnaceae	0.7	1.4	1.9	1.9	1.8	1.9	2.6	4.0	2.6	3.0	2.0	1.5	3.0	2.6	2.0	4.0	2.0	2.5	2.7	3.3	2.7	3.4	3.0	3.2	2.3	3.0	2.6	3.5	3.6	3.0	3.0
ubiaceae	0.9	1.0	0.6	1.3	0.2	1.2	0.5	0.7	0.1	0.5	0.7	0.3	1.0	0.0	0.3	0.8	0.3	0.5	0.5	1.2	0.7	1.0	0.8	1.0	0.3	0.5	1.2	1.0	1.3	1.0	1.2
utaceae	2.5	1.0	1.3	1.1	1.8	3.4	1.8	1.4	0.7	1.3	0.7	2.0	0.7	0.8	1.0	0.4	2.0	0.8	1.0	0.8	1.5	1.0	1.3	2.4	1.7	1.2	1.6	1.2	2.0	1.8	2.7
olygonaceae	0.0	0.5	0.0	0.0	0.2	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
antalaceae	0.0	1.0	0.3	0.0	0.4	0.7	0.0	0.9	0.1	0.0	0.5	0.3	0.1	0.0	0.3	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.3	0.8	0.0	0.7	0.0	0.0	0.0
crophulariaceae	0.8	0.2	0.3	0.4	1.1	0.5	0.2	1.0	1.0	0.3	0.0	0.9	0.0	1.3	0.3	0.8	0.5	1.0	0.7	0.8	1.2	1.6	0.7	1.3	1.0	0.3	1.0	0.6	1.6	1.0	1.2
terculiaceae	0.8	2.1	1.5	0.8	1.4	0.8	1.4	1.8	1.5	0.5	0.7	1.2	0.5	1.3	1.5	1.4	1.1	1.3	0.7	1.4	1.2	1.6	1.5	0.8	0.6	1.0	1.0	1.0	1.0	1.3	0.6
ymelaeaceae	2.5	2.5	2.4	1.9	2.3	4.0	2.8	3.5	3.5	2.0	1.3	2.5	1.0	4.0	2.7	3.5	2.0	2.5	2.7	1.4	2.8	2.0	0.7	2.4	2.5	1.6	2.7	1.7	1.8	2.1	2.0
inaceae	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
upressaceae	1.4	0.7	0.6	0.7	0.4	1.5	2.6	2.0	1.8	0.5	1.3	0.3	0.5	0.8	0.3	2.5	0.8	3.0	1.0	1.8	2.5	1.3	2.1	2.0	1.7	3.3	2.2	1.2	2.0	1.5	1.3
nknowns	2.2	1.9	2.3	1.6	2.4	2.3	0.9	3.1	0.6	3.5	2.4	2.1	2.0	2.6	2.8	2.2	4.1	4.1	3.2	3.0	1.6	3.6	2.7	3.1	4.3	0.7	3.3	2.4	2.1	3.5	3.0
pores	5.5	11.8	11.2	7.4	9.6	8.4	7.0	7.3	10.1	8.3	7.5	13.2	8.3	13.0	9.6	9.4	11.0	9.9	10.0	7.0	7.5	9.0	9.9	8.5	5.7	6.4	6.4	7.5	9.0	8.8	9.7
OLLEN SUM	887	980	1116	899	558	590	570	564	739	621	667	669	808	531	661	485	651	607	742	782	865	751	944	743	689	607	923	953	940	776	935

APPENDIX K.

ONE-WAY ANALYSIS OF VARIANCE

A. NUWEVELDBERG POLLEN TRAP DATA - 1986 & 1987.

H_o : THERE IS NO DIFFERENCE IN THE MEAN OF THE POLLEN TRAP DATA FROM EACH AREA FROM 1986 AND 1987.

H_a : THERE IS A DIFFERENCE IN THE MEAN OF THE POLLEN TRAP DATA FROM EACH AREA FROM 1986 AND 1987.

Acceptable significance level = 0.05.
Df (numerator ; $Ms_{between}$) = 1 (k-1).
Df (denominator ; Ms_{within}) = 22 (N-k).
F value $_{(0.05)}$ = 4.30.
$F_{obs} > 4.30$, then H_o is accepted.

FAMILY	F-STATISTIC	PROBABILITY (** - Ho accepted)
Poaceae	2.2953	0.1440
Cyperaceae	0.0566	0.8141
Iridaceae	4.3029	0.0500 **
Liliaceae	0.0213	0.0885
Labiatae	0.5874	0.4516
Asteraceae	7.0654	0.0144 **
Fabaceae	0.2680	0.6098
Ericaceae	0.0503	0.8247
Chenopodiaceae	0.3826	0.5426
Mesembryanthemaceae	1.8123	0.1919
Aizoaceae	0.9765	0.3336
Plantaginaceae	1.2639	0.2730
Campanulaceae	4.2927	0.0502
Caryophyllaceae	3.3212	0.0820
Tiliaceae	11.4384	0.0027 **
Thymelaeaceae	0.0000	1.0000
Acanthaceae	10.2875	0.0041 **
Bignoniaceae	8.5171	0.0080 **
Rosaceae	14.7527	0.0009 **
Euphorbiaceae	1.4667	0.2387
Malvaceae	1.3259	0.2619
Selaginaceae	0.8457	0.3677
Geraniaceae	2.4409	0.1325
Scrophulariaceae	3.5439	0.0731
Salicaceae	0.1138	0.7391
Ranunculaceae	0.0072	0.9329
Sterculiaceae	0.0037	0.9522
Polygalaceae	13.1897	0.0015 **
Polygonaceae	13.1663	0.0015 **
Pinaceae	0.8250	0.3736

ONE WAY ANALYSIS OF VARIANCE.

B. NUWEVELDBERG SURFACE SAMPLE DATA - 1986 & 1987.

H_o : THERE IS NO DIFFERENCE IN THE MEANS OF THE POLLEN COUNTS FROM EACH ZONE. FROM 1986 & 1987.

H_a : THERE IS A DIFFERENCE IN THE MEANS OF THE POLLEN COUNTS FROM EACH ZONE. FROM 1986 & 1987.

The acceptable significance levels = 0.05.

Df (numerator ; $MS_{between}$) = 1.

Df (denominator ; MS_{within}) = 22.

F-value $_{(0.05)}$ = 4.30

$F_{obs} > F_{4.30}$, then H_o is accepted.

FAMILY	F-STATISTIC	PROBABILITY (** = Ho accepted)
Poaceae	0.4557	0.5067
Cyperaceae	0.4900	0.8268
Juncaceae	1.0000	0.3282
Iridaceae	4.2428	0.0514
Liliaceae	0.3908	0.5383
Labiatae	5.4762	0.0288 **
Asteraceae	21.8950	0.0001 **
Fabaceae	0.6978	0.4125
Ericaceae	4.8629	0.0382 **
Chenopodiaceae	0.0014	0.9703
Mesembryanthemaceae	1.2622	0.2733
Aizoaceae	0.0281	0.8685
Plantaginaceae	7.1959	0.0136 **
Campanulaceae	1.0197	0.3236
Caryophyllaceae	1.0000	0.3282
Tiliaceae	16.8960	0.0005 **
Thymelaeaceae	0.5779	0.4552
Acanthaceae	18.1080	0.0003 **
Bignoniaceae	17.7139	0.0004 **
Rosaceae	14.5418	0.0009 **
Euphorbiaceae	2.1883	0.1532
Malvaceae	2.4473	0.1320
Geraniaceae	9.5823	0.0053 **
Sterculiaceae	9.6826	0.0051 **
Polygonaceae	30.2854	0.0000 **
Polygalaceae	4.9520	0.0366 **
Pinaceae	0.4342	0.5168
Salicaceae	0.6670	0.4229
Selaginaceae	8.3251	0.0086 **
Ranunculaceae	0.1346	0.7172

GLOSSARY OF ABBREVIATIONS.

ANOVA	- Analysis of Variance.
BMDP	- Bio-medical Data Processing.
BP	- Before Present.
BRI	- Botanical Research Institute.
^{0}C	- Degrees Celcius.
CSIR	- Council for Scientific and Industrial Research.
IGBP	- International Geosphere-Bioshpere Programme.
LM	- Light Microscope.
LS	- Longitudinal Section (of the pollen grains).
SASQUA	- South African Society for Quaternary Research.
SEM	- Scanning Electron Microscope.
SPSS	- Statistical Package for the Social Sciences.
TEM	- Transmission Electron Microscope.
TS	- Transverse Section (of the pollen grains).
TWISA	- Two-Way Indicator Species Analysis.
TWINSPAN	- Two-Way Indicator Species Analysis (Computer Programme).

3. NUWEVELDBERG: CONTEMPORARY POLLEN TRAP DATA - 1986.

Trap No.	1	2	3	4	7	8	9	10	11	12	14	16
Poaceae	24.0	19.7	35.0	32.0	0.6	16.0	17.0	18.5	20.0	14.0	24.4	16.0
Cyperaceae	5.0	4.0	4.8	2.6	0.3	13.0	17.0	17.1	11.0	4.3	2.6	2.4
Iridaceae	1.0	0.4	0.0	1.1	0.0	0.9	0.2	2.8	0.6	1.7	1.7	1.7
Liliaceae	0.8	0.4	0.2	0.0	0.0	2.08	2.4	1.1	3.6	0.4	0.4	0.0
Labiatae	0.6	0.5	2.5	1.8	0.0	5.8	6.9	7.5	6.5	1.5	2.6	1.9
Asteraceae	20.0	31.0	7.5	12.3	1.0	9.8	6.7	9.0	13.6	21.3	11.5	23.9
Fabaceae	15.0	12.6	11.2	9.8	0.9	10.6	10.8	13.5	11.0	11.4	8.7	14.2
Ericaceae	3.0	1.3	0.4	1.8	0.1	0.6	0.0	0.2	0.8	0.9	0.0	0.0
Chenopodiaceae	1.4	3.3	3.5	2.2	0.2	1.5	0.4	0.4	0.4	3.9	1.7	4.1
Mesems.	2.0	2.4	2.3	1.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Aizoaceae	2.2	0.4	1.9	1.1	0.0	0.9	0.2	0.2	0.2	6.8	1.9	3.2
Plantaginaceae	2.0	0.7	1.4	1.8	0.0	0.6	0.8	0.8	1.8	0.9	0.4	1.9
Campanulaceae	1.6	2.0	1.9	0.9	0.0	0.9	0.6	0.8	1.6	1.5	0.4	0.9
Caryophyllaceae	0.8	1.1	1.9	0.9	0.0	0.0	0.6	1.5	1.5	0.9	0.0	0.2
Tiliaceae	2.7	1.6	1.4	3.1	0.0	1.7	1.5	2.9	2.8	3.1	1.3	5.2
Thymelaeaceae	3.9	3.7	2.9	2.7	0.0	1.3	0.2	1.5	0.8	1.9	1.5	2.2
Acanthaceae	0.8	1.3	1.0	2.0	0.0	1.7	3.2	1.7	3.5	2.6	2.0	2.6
Bignoniaceae	3.3	2.0	2.9	4.9	0.0	2.8	1.1	2.8	3.0	3.5	1.9	5.2
Rosaceae	2.2	0.5	3.1	3.6	0.0	2.2	0.8	2.5	1.6	1.9	2.3	0.9
Euphorbiaceae	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Malvaceae	1.2	0.7	0.8	1.5	0.1	0.7	0.0	0.4	0.0	0.0	0.2	0.0
Selaginaceae	0.0	0.0	0.0	0.0	0.0	0.6	0.0	0.8	0.6	3.9	1.3	3.5
Geraniaceae	0.4	0.4	1.4	2.7	0.3	0.7	1.7	0.4	0.6	1.7	1.7	1.5
Scrophulariaceae	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0..	0.9	0.0	0.0
Salicaceae	0.8	0.7	0.4	0.0	96.0	7.0	19.0	7.3	5.0	0.0	3.0	0.0
Ranunculaceae	0.0	0.0	0.0	0.0	0.0	2.6	3.2	3.5	3.5	0.0	0.2	0.6
Sterculiaceae	0.2	2.0	4.0	1.5	0.3	1.7	0.6	0.8	1.8	2.2	0.6	0.6
Polygalaceae	0.4	0.4	0.8	0.2	0.0	0.2	0.0	0.4	0.2	0.0	0.4	0.2
Polygonaceae	0.8	0.7	1.2	2.2	0.0	1.5	3.0	1.5	2.8	1.7	1.7	1.9
Pinaceae	1.4	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	1.7	4.9	0.4
Onograceae	0.0	0.0	0.0	1.3	0.0	0.4	0.0	0.0	0.2	0.0	0.0	0.2
Unknown	0.8	0.4	0.8	0.9	0.0	1.1	0.2	0.4	1.6	0.4	0.0	1.3
Spores	0.2	5.4	0.6	3.8	0.0	0.7	1.1	0.0	0.2	0.0	19.7	0.6
POLLEN SUM	490	546	484	549	726	539	464	480	493	458	532	465

3. NUWEVELDBERG: CONTEMPORARY POLLEN TRAP DATA - 1987.

Trap No.	1	2	3	5	6	7	8	10	11	12	13	14	15a	15b	16	17
Poaceae	29.0	19.0	32.0	21.0	24.0	9.0	13.0	15.0	18.0	27.0	22.0	36.0	27.0	23.0	29.0	53.0
Cyperac.	3.0	2.1	3.0	2.3	5.0	3.5	17.0	12.0	14.0	6.0	3.5	1.0	4.0	1.6	2.6	1.6
Iridaceae	0.5	0.4	1.2	1.0	1.0	0.6	0.3	0.0	0.0	0.0	0.6	0.6	0.3	0.0	1.0	0.5
Liliaceae	0.5	0.7	0.5	0.2	0.0	0.0	3.0	2.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Labiatae	0.5	2.1	1.0	1.0	2.5	2.0	4.4	6.0	3.0	2.3	2.0	1.0	2.4	1.0	1.0	1.2
Aster.	32.0	46.0	26.2	40.0	32.0	23.6	25.4	15.7	24.5	19.6	28.6	32.0	30.9	48.0	35.7	17.0
Fabaceae	10.0	8.0	13.2	9.4	9.9	4.9	9.0	16.2	13.9	16.9	13.7	12.0	14.2	29.0	16.0	8.9
Erica.	1.3	1.5	1.7	1.0	0.7	0.6	1.3	0.2	0.6	0.3	0.3	0.0	0.0	0.0	0.0	0.0
Chenopod.	2.3	3.0	3.0	1.6	1.3	3.0	1.0	1.0	1.2	3.8	5.0	3.5	3.2	1.6	4.2	1.8
Mesems.	0.8	0.4	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.6	0.0	0.0	0.5	0.0	0.0
Aizoaceae	2.8	2.4	1.5	1.6	2.2	0.0	0.0	0.0	0.0	3.2	2.3	0.3	1.2	2.0	1.6	1.0
Plantag.	1.8	1.1	1.7	2.0	3.3	2.0	1.0	2.4	0.3	2.0	3.8	0.3	1.8	1.0	1.0	1.6
Campan.	0.5	0.6	0.0	0.0	0.7	0.0	0.0	2.0	0.6	1.4	0.0	0.0	0.0	0.0	0.0	0.9
Caryoph.	0.5	0.2	0.0	0.0	0.0	0.0	2.3	1.5	1.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tiliaceae	0.5	1.1	0.5	0.4	0.5	1.5	0.3	0.2	0.0	0.3	0.6	0.0	0.6	0.0	1.0	3.0
Thymel.	1.0	3.4	3.2	2.3	4.7	0.9	2.3	0.7	2.7	2.6	2.6	1.0	1.8	3.0	1.6	1.4
Acanth.	1.8	1.7	0.5	1.0	0.0	0.9	0.7	0.0	1.2	0.3	1.0	1.0	1.8	0.3	0.0	0.8
Bignonia.	1.3	0.7	1.7	2.3	0.5	0.0	1.0	0.7	0.9	2.6	1.2	2.0	2.6	1.6	1.0	3.3
Rosaceae	0.0	0.7	1.0	1.2	0.0	0.6	0.7	0.0	0.6	0.6	0.3	0.0	0.0	0.3	0.0	0.0
Euphorbia.	2.0	0.0	0.2	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Malvaceae	3.0	0.2	1.0	4.0	2.9	0.0	1.0	0.7	1.2	0.0	1.0	1.0	0.2	0.3	0.0	0.4
Selagina.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.0	1.0	0.0	0.0	0.0	2.6	0.5
Gerania.	0.8	0.6	1.0	0.0	0.7	0.9	2.0	0.2	1.2	1.4	0.0	0.0	1.5	0.5	0.0	0.0
Scroph.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.7	2.0	2.0	3.5	2.2	1.6	1.2
Salicac.	0.0	0.0	0.0	4.0	5.6	45.0	11.0	20.0	5.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ranuncul.	0.0	0.0	0.0	0.0	0.0	0.0	2.3	2.6	4.6	0.0	0.0	0.6	0.0	0.0	0.0	0.0
Stercul.	2.8	1.9	1.5	0.4	2.2	1.2	1.0	1.3	1.5	0.6	0.0	0.0	1.5	2.0	0.0	0.0
Polygal.	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Polygon.	0.0	0.2	0.2	0.4	0.0	0.0	0.0	0.0	0.0	1.4	0.0	1.0	0.9	1.0	0.5	0.7
Pinaceae	0.0	0.4	0.2	0.2	0.5	0.0	0.0	0.0	0.0	0.6	0.3	4.0	0.0	0.0	0.0	0.2
Onograc.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Unknown	1.3	1.0	1.0	0.6	0.5	0.0	0.0	0.0	0.0	0.3	0.9	0.3	0.6	0.0	1.0	0.5
Spores	0.5	0.0	0.2	1.4	0.2	0.1	0.0	0.3	0.6	0.3	0.4	0.0	0.6	0.8	0.0	0.1
POLLEN SUM	397	535	404	486	448	347	298	454	327	346	344	315	340	372	189	571

4. NUWEVELDBERG: CONTEMPORARY SURFACE SAMPLE DATA - 1986.

Surface Sample	1	2	3	6	7	8	10	11	12	14	15	16
Poaceae	25.0	16.8	27.5	22.2	14.1	18.6	14.0	14.3	11.5	39.0	23.1	17.2
Cyperaceae	6.0	6.5	2.9	3.2	5.6	12.3	11.1	13.0	5.8	3.4	2.3	2.8
Iridaceae	1.5	1.4	1.2	0.9	0.0	0.6	0.6	0.3	0.5	0.0	0.9	0.8
Liliaceae	0.3	0.7	0.0	0.0	0.0	1.5	1.5	0.9	0.0	0.0	0.0	0.0
Labiatae	1.5	4.8	2.9	6.1	4.9	10.5	12.3	7.3	1.1	4.4	5.4	4.4
Asteraceae	21.0	22.0	18.6	20.2	13.2	16.7	15.2	16.4	22.7	14.6	26.0	22.4
Fabaceae	10.1	10.2	10.8	9.3	6.6	7.2	12.6	9.7	16.9	11.2	11.4	13.3
Ericaceae	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Chenopodiaceae	2.4	2.3	2.9	1.8	0.0	0.3	0.3	0.3	2.5	0.6	1.1	1.9
Mesems.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.7	0.0	2.3	0.0
Aizoaceae	0.9	1.9	0.3	0.9	0.0	0.0	0.0	0.0	3.7	0.3	1.7	4.9
Plantaginaceae	2.4	3.1	2.7	7.6	1.3	1.5	2.0	3.9	4.4	1.9	3.4	2.2
Campanulaceae	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.3	0.0	0.0	0.3	0.6
Tiliaceae	4.4	5.7	4.5	3.5	2.9	1.9	1.5	2.1	1.4	1.9	2.0	4.4
Thymelaeaceae	3.8	3.4	2.3	4.1	1.3	0.3	2.0	0.9	4.9	1.9	3.7	3.1
Acanthaceae	4.8	3.1	4.5	2.1	1.0	2.5	3.2	2.4	1.1	2.5	1.4	3.1
Bignoniaceae	2.9	7.1	5.1	4.7	0.0	4.0	4.7	4.6	5.5	4.7	6.3	6.4
Rosaceae	2.1	1.4	2.7	0.9	1.3	0.0	1.2	0.3	0.3	1.2	0.3	0.0
Euphorbiaceae	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Malvaceae	1.2	0.6	0.6	2.1	2.6	0.6	0.9	0.9	0.5	0.3	1.1	0.6
Geraniaceae	2.1	1.1	3.3	1.2	0.0	1.9	1.8	1.8	1.9	3.4	1.4	0.3
Sterculiaceae	1.5	0.6	2.1	0.0	3.3	0.0	0.0	0.0	0.3	0.0	0.0	0.0
Polygonaceae	4.0	1.9	4.2	1.8	3.3	7.7	3.8	4.6	4.7	4.9	2.0	1.4
Polygalaceae	0.0	0.3	0.6	0.3	0.3	0.0	0.0	0.6	1.4	0.3	0.3	0.0
Pinaceae	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.4	0.0	0.0	0.0
Salicaceae	0.0	0.0	0.0	3.5	36.0	3.1	3.8	6.1	0.0	0.0	0.0	0.0
Scrophulariaceae	0.0	0.0	0.0	0.6	0.0	0.0	0.0	0.0	1.1	0.0	0.3	1.7
Selaginaceae	0.9	4.8	0.0	2.3	0.7	3.1	2.9	2.7	1.4	0.6	0.9	3.3
Viscaceae	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.4	1.9
Ranunculaceae	0.0	0.0	0.0	0.0	0.0	4.0	4.9	3.6	0.5	0.6	0.0	0.8
Unknown	1.8	0.3	0.3	0.0	0.0	0.0	0.3	1.2	0.8	0.9	0.3	1.4
Spores	0.0	0.0	0.0	0.9	1.6	1.2	1.5	1.5	1.1	0.9	0.6	1.1
POLLEN SUM	339	352	335	342	304	323	342	329	365	321	350	361

4. NUWEVELDBERG: CONTEMPORARY SURFACE SAMPLE DATA - 1987.

Surface sample	1	2	3	5	7	9	10	11	12	14	15	16
Poaceae	22.0	22.0	23.0	24.0	8.4	19.0	20.0	23.0	18.0	30.0	28.0	29.0
Cyperaceae	4.5	4.2	3.0	4.0	2.3	18.0	19.0	19.0	3.1	2.0	2.0	0.3
Iridaceae	0.7	0.4	0.4	0.3	0.0	0.0	0.0	0.0	0.3	0.0	1.4	0.6
Liliaceae	0.0	0.0	0.4	0.0	0.5	2.0	0.7	1.1	0.0	0.4	0.0	0.0
Labiatae	2.7	3.0	2.6	3.0	3.3	3.4	4.7	3.6	3.4	3.5	3.0	2.1
Asteraceae	39.0	38.5	35.3	30.2	14.3	22.0	21.3	28.5	39.0	34.3	36.0	34.0
Fabaceae	9.4	9.5	11.9	9.0	7.0	9.0	9.5	7.2	13.0	10.0	00.3	12.5
Ericaceae	1.4	0.4	0.9	0.6	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0
Chenopodiaceae	2.4	2.0	1.3	2.0	0.9	0.0	0.0	0.4	2.8	0.4	0.7	3.3
Mesems.	0.7	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Aizoaceae	2.0	2.3	2.2	1.2	0.5	0.0	0.0	0.0	1.9	1.2	2.0	3.0
Plantaginaceae	2.4	1.5	1.3	3.0	0.0	0.6	2.0	1.4	0.3	2.3	1.0	0.6
Campanulaceae	0.0	0.0	0.0	0.0	0.0	2.8	1.4	0.4	0.0	0.0	0.0	0.0
Tiliaceae	1.0	0.8	2.6	0.6	0.9	1.0	0.2	0.7	1.5	1.2	1.4	2.1
Thymelaeaceae	3.7	5.3	4.3	3.7	0.0	1.2	0.7	1.1	5.2	0.8	3.0	1.2
Acanthaceae	1.7	2.0	1.4	0.9	0.0	0.0	0.2	0.0	0.0	0.4	0.7	2.4
Bignoniaceae	1.4	2.7	3.0	2.3	0.0	2.5	2.1	2.5	1.5	1.5	3.0	3.0
Rosaceae	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0
Euphorbiaceae	0.7	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Malvaceae	0.0	0.8	0.0	1.4	2.0	0.6	0.5	0.0	1.0	0.8	0.0	0.0
Geraniaceae	0.0	0.0	0.4	0.0	0.0	1.0	1.0	0.0	0.0	1.5	1.4	0.6
Sterculiaceae	3.4	2.3	2.6	3.7	0.9	1.0	2.0	1.4	0.0	1.2	1.0	4.0
Polygonaceae	2.0	1.2	0.9	0.3	0.0	0.6	0.0	0.4	1.2	1.2	0.0	0.6
Polygalaceae	0.0	0.0	0.0	0.3	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0
Pinaceae	0.0	0.0	0.4	0.3	0.0	0.0	0.0	0.0	0.0	1.2	0.0	0.0
Salicaceae	0.0	0.0	0.0	7.0	60.0	12.0	12.0	6.0	0.0	5.4	0.0	0.0
Scrophulariaceae	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Selaginaceae	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	5.0	1.2	3.4	0.6
Viscaceae	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ranunculaceae	0.0	0.0	0.0	0.0	0.0	4.7	3.3	3.2	0.0	0.0	0.0	0.0
Unknown	0.0	1.2	0.9	2.0	0.0	1.2	0.0	0.0	2.2	0.0	0.0	0.0
Spores	0.0	0.4	0.2	0.6	1.0	0.9	0.3	0.2	0.7	0.1	0.0	0.0
POLLEN SUM	296	263	231	353	215	321	428	279	324	259	292	336

SNEEUBERG FOSSIL POLLEN DATA CONTINUED.

epth (cm)	155	160	165	170	175	180	185	190	195	200	205	210	215	220	225	230	235	240	245	250	255	260	265	270	275	280	285	290	295	300	305	310
oaceae	10.0	15.0	15.0	13.0	15.0	15.0	12.0	10.0	13.4	10.0	13.0	13.0	12.0	11.0	11.0	14.0	16.0	12.0	11.0	13.0	8.3	9.0	8.5	10.0	7.6	8.4	9.0	9.0	10.0	9.2	7.0	9.0
yperaceae	4.4	9.0	7.6	6.8	6.0	5.0	8.0	7.5	9.0	7.0	6.0	4.5	6.0	9.0	7.0	9.0	8.6	5.0	8.7	9.0	7.1	10.0	8.6	11.0	11.0	6.5	9.0	8.0	9.0	7.4	14.0	10.0
estionaceae	7.7	19.0	13.0	19.0	17.0	14.0	15.0	15.0	13.0	13.0	13.0	13.0	10.0	13.0	12.0	11.0	11.0	11.0	15.4	15.0	20.0	14.6	14.0	12.0	17.0	12.0	12.0	8.4	15.0	14.0	13.0	14.0
maryllidaceae	1.0	0.7	0.4	1.3	0.9	0.8	0.7	0.9	0.8	0.6	0.4	1.0	0.9	0.5	0.7	0.7	1.3	1.0	1.2	1.3	0.5	0.8	1.2	1.3	1.1	0.8	0.6	0.7	0.2	0.7	1.1	0.3
umariaceae	0.0	0.0	0.6	0.0	0.0	0.6	0.9	0.0	0.0	0.0	0.1	0.0	0.4	0.0	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
uncaceae	0.3	0.7	0.6	0.4	0.6	0.4	0.2	0.3	0.4	0.2	1.3	0.7	0.4	0.3	0.2	1.3	1.3	0.7	0.4	0.2	0.3	0.6	1.2	0.0	0.8	0.8	0.8	0.3	0.5	0.0	0.0	0.5
abiatae	2.5	2.3	1.5	2.2	1.8	1.6	2.0	2.0	1.6	1.6	2.0	2.5	1.2	1.3	1.6	1.9	2.0	2.0	1.3	0.9	0.8	1.7	1.6	2.3	1.1	1.9	1.5	1.4	1.7	0.6	0.0	2.7
iliaceae	0.6	0.7	0.3	0.4	0.3	0.4	0.8	0.6	0.4	0.4	0.3	0.2	0.5	0.8	0.7	0.2	0.3	0.3	0.4	0.5	0.3	0.4	0.3	0.5	0.4	0.6	0.6	0.7	0.7	0.9	0.5	0.5
xalidaceae	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.4	0.0	0.2	0.0	0.0	0.0	0.7	0.0	0.0	0.0	0.2	0.0	0.8	0.6	0.0	0.4	0.6	0.4	0.3	0.0	0.6	0.0	0.0
anunculaceae	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
izoaceae	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
mbelliferae	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
steraceae	18.7	17.0	17.0	13.0	14.0	17.0	16.5	17.0	15.0	17.0	13.0	17.0	18.4	19.0	14.0	13.0	16.0	20.3	13.0	14.7	12.8	12.4	14.0	15.0	16.0	22.5	16.0	18.0	17.0	18.7	12.0	19.0
runiaceae	1.2	0.3	1.0	0.8	2.0	1.4	0.5	1.2	0.8	1.0	1.1	1.2	1.3	1.3	1.1	1.8	1.1	0.7	1.1	0.3	0.5	2.0	0.0	1.3	0.8	1.4	1.0	1.7	0.7	2.1	1.6	1.8
ampanulaceae	0.6	0.0	0.4	0.4	0.4	0.4	0.5	0.6	0.4	0.2	0.0	0.7	0.4	0.0	0.9	0.5	0.0	0.0	0.4	0.6	0.3	0.6	1.6	0.5	0.0	0.3	0.0	0.0	0.4	0.0	0.0	0.8
aryophyllaceae	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0
rucifereae	0.0	0.0	0.0	0.0	0.7	0.6	0.5	0.5	0.0	0.4	0.0	0.0	0.3	0.0	0.9	0.0	0.0	2.0	0.6	0.8	1.0	0.2	0.7	1.0	0.4	0.0	1.0	0.5	1.2	0.9	0.0	1.0
ricaceae	12.0	9.0	7.0	7.9	9.0	9.7	10.0	8.0	8.0	10.0	9.0	6.0	7.0	7.5	9.0	8.6	5.3	7.1	9.3	6.8	8.8	8.0	7.5	7.3	5.4	7.0	5.0	6.0	7.5	6.1	7.4	7.0
abaceae	3.3	4.2	4.1	2.7	4.0	5.0	4.0	4.0	4.6	5.3	5.0	4.0	6.0	5.4	5.6	6.6	7.2	6.0	6.3	5.5	6.7	5.2	6.0	4.0	5.5	5.3	4.4	5.2	5.1	4.9	3.0	5.0
eraniaceae	0.0	0.3	0.3	0.0	0.6	0.8	1.4	1.3	0.6	1.8	1.3	0.7	2.0	1.3	1.1	0.8	1.1	1.3	0.0	0.4	0.0	1.0	1.1	1.0	0.4	0.3	1.3	1.7	1.2	0.3	0.0	0.8
ridaceae	1.0	1.6	0.9	1.3	0.9	0.8	1.1	0.6	1.0	1.0	1.5	1.2	1.1	1.3	0.7	1.2	1.1	1.3	0.8	1.4	0.5	1.2	1.3	1.3	0.4	1.5	1.5	0.3	1.2	0.3	2.0	0.5
alvaceae	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	0.3	0.0	0.2	0.0	0.0	0.2
ontiniaceae	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
olygalaceae	1.6	0.7	0.3	0.0	0.4	0.6	0.7	0.9	0.2	1.0	0.3	0.5	0.2	0.3	0.0	0.2	0.0	0.0	0.0	0.5	0.0	0.6	0.0	0.5	0.6	0.3	0.0	0.5	1.4	1.4	0.5	0.5
roteaceae	5.0	5.0	3.0	3.7	3.7	4.6	3.0	5.0	3.6	4.0	5.0	6.5	5.0	6.0	6.5	4.4	5.6	5.6	4.8	5.0	5.0	4.0	6.0	2.8	3.4	3.3	7.0	6.3	5.3	5.2	10.0	2.5
osaceae	1.2	2.3	1.3	2.0	2.0	1.8	1.6	2.2	1.4	1.3	1.0	2.7	2.0	1.3	2.0	1.4	2.4	2.3	1.5	1.0	2.5	2.4	1.0	1.0	0.8	2.8	1.8	2.4	2.0	2.4	1.1	2.6
hamnaceae	4.0	4.8	3.3	2.7	3.0	2.0	3.0	4.0	2.8	2.1	3.0	3.2	3.5	3.7	3.0	1.7	3.0	2.3	3.1	3.0	3.0	2.8	1.8	2.8	2.7	2.5	3.0	3.3	3.1	3.3	2.0	2.4
ubiaceae	1.7	1.7	1.6	1.4	1.6	1.6	1.4	2.5	0.8	2.6	1.8	2.0	0.9	2.4	0.7	0.7	0.5	0.0	1.0	0.0	0.9	0.8	0.7	0.6	0.0	0.3	0.0	0.7	0.2	0.3	0.5	0.5
utaceae	2.0	1.7	2.7	1.7	2.7	2.0	0.7	0.8	1.4	1.4	1.6	1.6	3.0	1.3	1.3	1.9	2.0	1.0	2.1	2.4	1.8	1.5	1.6	3.0	2.3	2.5	2.0	3.0	2.4	2.0	4.0	2.0
olygonaceae	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.5
antalaceae	0.3	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.9	0.6	0.0	0.0	0.0	0.4	0.0	0.3	0.0	0.4	0.0	0.3	0.0	0.0	0.5	0.0	0.0	0.3	0.3	0.0	0.0	0.0	0.0
crophulariaceae	1.6	1.3	0.9	1.5	1.0	1.4	0.0	0.4	0.8	0.4	0.4	0.5	2.0	1.7	1.8	1.0	0.3	2.3	1.1	0.9	1.0	1.6	1.0	0.5	1.5	0.9	2.0	1.4	1.0	2.1	1.0	0.8
terculiaceae	0.8	0.7	0.8	0.8	2.0	0.6	1.1	2.0	0.8	0.7	1.2	0.9	2.0	1.0	0.9	0.5	0.2	1.7	0.8	0.6	1.0	0.6	1.1	0.0	0.0	0.6	1.5	0.7	1.0	1.2	0.5	1.0
hymelaeaceae	2.6	2.0	2.1	1.7	0.8	1.2	2.3	1.7	2.0	2.2	3.0	1.0	1.4	3.0	2.6	2.6	2.0	1.7	2.0	2.0	1.5	1.2	1.6	3.5	1.5	1.9	1.3	1.0	1.4	0.9	2.0	0.7
inaceae	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
upressaceae	1.6	2.3	2.1	1.4	1.3	1.7	2.0	2.4	2.7	2.4	3.0	1.7	3.0	2.0	2.2	2.6	3.0	2.0	2.7	2.0	4.5	3.7	4.4	3.9	3.4	3.6	3.8	6.0	2.2	3.6	2.0	5.0
nknowns	0.6	1.5	2.5	2.8	3.1	3.5	2.4	2.1	3.7	3.8	3.7	3.1	4.4	2.8	3.1	3.6	4.5	3.5	4.1	5.4	4.6	4.2	4.9	3.4	0.8	3.1	4.1	3.5	3.1	4.5	8.5	3.9
pores	8.8	10.1	9.3	10.0	5.4	7.7	9.0	7.6	12.7	7.0	9.2	8.9	8.0	3.0	8.1	5.8	5.0	7.3	7.4	6.6	5.8	7.6	9.0	7.8	6.1	7.2	6.9	7.2	5.5	6.4	7.0	6.5
OLLEN SUM	641	1197	1645	1183	899	1046	883	1281	1037	948	680	802	920	749	890	832	755	603	1047	1173	1588	994	1224	792	525	646	797	574	845	675	377	1232